

## Free Communications, Oral Presentations: Heat and Hydration I

Wednesday, June 16, 2004, 8:00AM-10:00AM, Room 338; Moderator: Douglas J. Casa, PhD, ATC

### Sweat Rate And Core Temperature Responses To Dehydration Induced Experimentally Versus During Actual Pre-Season Practice In College Football Players

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Heart rate and core temperature rise as dehydration progresses in subjects exercising continuously during heat stress studies in environmental chambers. Additionally, sweat rates measured in experimentally controlled conditions have been used to estimate sweat loss during sport activity. These data may be useful for athletes such as runners or cyclists who train and compete under similar field conditions however they may not accurately reflect the physiological responses of football (FB) players who exercise intermittently in equipment. The purpose of this study was to compare core temperature (Tc) and sweat rate responses of FB players during a standard dehydration protocol to the same responses during FB practice in hot and humid conditions. Ten college FB players age=21.2±1.14yr, wt=116.6±16kg, ht=188±4.8cm and body fat =18±5.5% participated in two separate experimental dehydration trials in an environmental chamber and then two days of field data collection during pre-season practices in August. The experimental protocol consisted of 60-90 min of continuous cycling and walking at a moderate intensity designed to reduce body weight (BW) by 2.6%. Tc, heart rate (HR) and percent dehydration (%Dehy) were measured during the experimental trials while subjects exercised in shorts, shirts and shoes. Field data was collected on two separate days (4 practices) during pre-season training while the players practiced in FB equipment. During both experimental and field conditions BW was measured to the ~ lb and %Dehy was determined by changes in BW. Sweat rates were calculated from pre-BW – post-BW – urine volume + fluid consumed/ exercise time. Tc was measured using flexible rectal thermistors in the experimental trials and ingestible sensors for the field data collection. Both are accurate and reliable instruments. Data were analyzed using repeated measures ANOVA, correlated t-tests and Pearson's r when indicated. Sweat rates were significantly different during FB

practice (2.091±0.56 L/hr) compared to experimental trials (1.813±0.33 L/hr), p<0.02. Significant linear trends were found for Tc, HR and %Dehy during the experimental trials, and significant correlations were found for Tc and %Dehy (r =.76, p<0.0001) and for Tc and HR (r =.59, p<0.0001). Conversely, no correlation was found between Tc and %Dehy during actual pre-season FB practice (r =0.197, p=.29). In every case, maximal Tc was reached at the end of the experimental trials when %Dehy was greatest. However, during field data collection nearly 1/3 of the time (31%) the highest recorded Tc occurred 45 to 90 min into the 135 min practices. Tc and sweat rate responses to continuous exercise in FB players participating in experimental dehydration trials do not accurately reflect actual Tc and sweat rate responses during pre-season FB practices.

### Sweat Rates And Fluid Turnover In Professional Football Players: A Comparison Of NFL Linemen Versus Backs

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Most teams in the National Football League (NFL) practice two times per day on consecutive days during July and August when it is frequently hot and humid. The combination of a large body surface area (BSA) and equipment results in high sweat rates (SwtR) in football players. Replacing large daily sweat losses with hypotonic fluids may predispose these athletes to sodium dilution. The purpose of this study was to measure SwtR in professional football players and compare the SwtR of larger linemen to backs and receivers (backs). Eight linemen (age=26.6±3.7 yr, Ht=192.7±5.8 cm, Wt=132.7±14.5 kg and BSA=2.62±0.16 m<sup>2</sup>) and four backs (age=25.3±4.6 yr, Ht=184±6.7 cm, Wt=88.65±4.9 kg and BSA=2.13±0.098 m<sup>2</sup>) participated in the study. SwtR data was collected during both practice sessions on two separate days the first week of August. An equal number of linemen and backs were studied on each day and environmental

conditions were similar (mean wet bulb in morning = 71.3 vs 66 °F and in afternoon = 77 vs 76.2 °F). The players wore full pads during the morning sessions (AM) and shells for the afternoon practices (PM). Subjects recorded nude body weights (BW) before and after each practice and voided their bladder completely post practice for volumetric measurements. SwtR was calculated as change in BW adjusted for fluids consumed and urine produced during practice. All players drank water and/or sports drinks only from their pre-measured and pre-labeled containers. Independent t-tests were used for statistical analysis. Height (p<0.05), BW (p<0.001) and BSA (p<0.0001) were all higher in linemen. Gross SwtR expressed in liters per hour were also higher in linemen (2.385±0.52 l · h<sup>-1</sup>) versus backs (1.408±0.66 l · h<sup>-1</sup>), p<0.001. When adjusted for BSA however, no differences existed in SwtR. The total volume of sweat lost during both practices was higher in linemen (6.868±1.034 l · d<sup>-1</sup> vs 4.11±2.287 l · d<sup>-1</sup>). Linemen consumed more fluids during practice (2030±849 ml · h<sup>-1</sup> vs 1179±753 ml · h<sup>-1</sup>), p<0.03 but produced less urine (53±73 ml versus 163.4±140.5 ml), p<0.02. Percent dehydration post practice was not different between linemen (-1.15±0.83 %) and backs (-1.06±0.76 %). NFL linemen sweat at higher overall rates and lose greater volumes of sweat during practices compared to smaller backs and receivers. They consume more fluids and produce less urine during practice and are not more dehydrated compared to backs. Sodium supplementation may be necessary in NFL players during pre-season due to high daily sweat losses in both smaller (4.1 l · d<sup>-1</sup>) and larger (6.9 l · d<sup>-1</sup>) players.

### Voluntary, Chronic Dehydration In Adolescent American Football Players

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Voluntary dehydration occurs during exercise in hot environments even when adequate amounts of fluid are readily available. We sought to determine if voluntary, chronic dehydration occurs in adolescents during *in situ* "two-a-days" American football practice over three consecutive practice sessions. The research design consisted of an observational study

with a test re-test design. Informed consent was obtained from parents/guardians of 19 Varsity level American football players (age =  $16.2 \pm 0.9$  yr, range 14 - 17 yr; height =  $179.7 \pm 4.9$  cm; weight =  $84.5 \pm 14.8$  kg; body mass index =  $26.2 \pm 4.8$  kg·cm<sup>2</sup>) from an all boys private preparatory school. Measures of hydration status (body mass and volume of fluid consumed) were recorded pre- and post-practice which lasted approximately 2.5 hr in South Florida ( $30.6 \pm 0.7$  °C,  $74.2 \pm 3.7\%$  relative humidity) in full equipment. The complete ( $n = 12$ ) body mass data sets (pre- and post-practice for Day 1 am, Day 1 pm, and Day 2 am) were analyzed using repeated measures ANOVA. Body mass data revealed significant ( $F_{5,55} = 11.656$ ,  $P \leq .001$ , power = 1.00) differences during and between practice sessions. *Post hoc* testing revealed that body mass became significantly ( $P = .029$ ) reduced 1.18% (1.0 kg) during the first morning practice. Body mass was also significantly ( $P = .01$ ) reduced 1.55% (1.3 kg) between the Day 2 post-practice measurement compared to the first measurement (Day 1 pre-am practice). Between the morning and afternoon practices on the first day, body mass was significantly ( $P = .001$ ) increased 1.67% (1.4 kg) however, during that afternoon practice, body mass was again significantly ( $P < .001$ ) reduced 1.30% (1.1 kg). Body mass did not significantly change between days of football practice but, by Day 2 pre-practice, body mass was significantly ( $P = .001$ ) reduced 2.11% (1.8 kg) compared to pre-practice the afternoon prior. Finally, body mass was significantly ( $P \leq .001$ ) reduced 1.15% (1.0 kg) during practice on the second day. Average fluid consumed over the three consecutive practice sessions was  $1772.8 \pm 158.4$  mL per practice (range =  $1304.2 - 2093.0$  mL). We conclude that adolescent American football players became significantly dehydrated during practice sessions and rehydrated adequately between practice sessions on the same day. However, the participants were chronically dehydrated between days of practice as they did not fully rehydrate overnight and reported to practice the following morning dehydrated. The short- or long-term mental and physical health consequences of chronic voluntary dehydration in adolescents are unknown.

### The Relationship Between Core Temperature, Percent Dehydration And Sweat Rates In NFL Players During Preseason Practices

Burkholder R, Fowkes Godek S, Sugarman E, Peduzzi C: Philadelphia Eagles, Philadelphia, PA, and West Chester University, West Chester, PA

NFL teams begin pre-season training camp during the summer months when it is often hot and humid predisposing players to thermal injury. Most medical professionals believe that dehydration is a primary cause of heat related disorders and that prevention rests with proper hydration. Additionally, dehydration in athletes has been linked to sweat rates (SwtR). Now that ingestible sensors allow accurate measurements of core temperature (Tc) during exercise the purpose of this field study was to evaluate the correlation between Tc, percent dehydration (%Dehy) and SwtR in professional football players during pre-season practices. Eight players who are first team veterans on an NFL team participated, (age= $27.13 \pm 3.4$  yr, height= $189.2 \pm 7.9$  cm, weight (BW)= $114.9 \pm 26$  kg and body surface area =  $2.4 \pm 0.3$  m<sup>2</sup>). Tc and SwtR were measured during the first 10 days of pre-season two-a-day training. Subjects ingested a temperature sensor the night before Tc measurements. Resting Tc was recorded 1 h prior to morning practice (AM) and then every 15-18 min during practice in full pads. Tc was also measured during the afternoon practice (PM) in 6 subjects who retained their sensors. Players recorded BW to the nearest ° lb before and after each practice and %Dehy was determined by weight loss. On two separate days SwtR was calculated using change in BW adjusted for fluid intake and urine produced. Repeated measures GLM and Pearson's  $r$  were used to assess Tc over time and correlations between Tc and SwtR and Tc and %Dehy. All correlations were calculated using  $n=14$  combining AM ( $n=8$ ) and PM ( $n=6$ ) data. A linear trend was found for Tc in both AM ( $p < 0.002$ ) and PM ( $p < 0.003$ ). In AM Tc rose from  $98.65^{\circ}\text{F}$  at rest to  $101.24^{\circ}\text{F}$  during live scrimmage at the end of practice. The highest Tc ranged from  $100.27$  to  $102.73^{\circ}\text{F}$  in AM and  $100.2$  to  $102.34^{\circ}\text{F}$  in PM. No correlations were found for Tc and %Dehy ( $r = 0.204$ ,  $p = 0.49$ ) or Tc and SwtR ( $r = 0.37$ ,  $p = 0.19$ ). SwtR was  $2.11 \pm 0.77$  L · hr<sup>-1</sup> and %Dehy was  $-1.4 \pm 0.49\%$ . On 5 occasions players reached a Tc  $> 102^{\circ}\text{F}$ , ( $102.2$  to  $102.73$ ) however their %Dehy was  $-.066 \pm 0.011\%$ , ranging from  $-0.98$  to  $-1.24\%$

which was consistently below the mean of  $-1.4\%$ . Additionally, The players who were most dehydrated had Tc  $< 102^{\circ}\text{F}$ , ( $-2.3\%$  Dehy and  $101.89^{\circ}\text{F}$ ,  $-1.97\%$  Dehy and  $101.1^{\circ}\text{F}$ , and  $-1.89\%$  Dehy and  $100.2^{\circ}\text{F}$ ). Data indicate that core temperature cannot be accurately predicted from either % dehydration or sweat rates in NFL players.

### Effects Of Active Dehydration On Cognitive Performance

Zuri RE, Cleary MA, Lopez RM, Jones LC: Florida International University, Miami, FL

Limited research suggests that cognition may be impaired by active dehydration induced by exercise in a hot, humid environment. We used the latest technological advances in computerized neuropsychological testing to identify the effects of acute active dehydration on cognitive response times. The research design consisted of a test-retest design with one experimental group. Ten healthy male participants ( $25.6 \pm 1.6$  years,  $80.3 \pm 4.3$  kg) were assessed in euhydrated and dehydrated conditions using the Headminder™ Cognitive Stability Index® test. Participants were actively dehydrated by  $3.27 \pm 0.08\%$  body mass loss via heat stress trial of treadmill exercise in a hot, humid environment ( $33.1 \pm 3.1$  °C,  $55.1 \pm 8.9\%$  relative humidity) followed by rest in a thermoneutral environment until core (rectal) body temperatures returned to baseline ( $50.2 \pm 17.05$  min, range =  $28 - 80$  min). Prior to both cognitive performance tests, participants rated motivation (on a 13 cm visual analog scale) and fatigue severity (on a 9-point Likert scale). Dependent t-tests were used to identify differences between the euhydrated and dehydrated conditions on all measures. Motivation ratings were not significantly different ( $t_9 = 2.181$ ,  $P = .057$ ) between conditions; however, ratings did reveal a  $17.86\%$  decrease from the euhydrated ( $8.4 \pm 1.8$  cm) to the dehydrated ( $6.9 \pm 2.9$  cm) condition. Fatigue severity ratings were significantly ( $t_8 = -5.774$ ,  $P = .001$ ) increased  $62.48\%$  from the euhydrated ( $2.00 \pm 1.41$ ) to the dehydrated ( $5.33 \pm 1.73$ ) condition. Cognitive testing revealed that the composite processing speed factor raw scores were significantly ( $t_9 = -3.329$ ,  $P = .009$ ) decreased  $8.33\%$  in the dehydrated ( $2.78 \pm .43$ ) compared to the euhydrated ( $3.03 \pm .32$ ) condition. No other composite scores were significantly different. Of the

subtests, the symbol scanning response time was significantly ( $t_9 = 6.692, P \leq .001$ ) decreased 16.16% in the dehydrated ( $3.16 \pm .57$  ms) compared to the euhydrated ( $3.76 \pm .17$  ms) condition. The response direction 1 response time was significantly ( $t_9 = 6.692, P \leq .001$ ) increased 4.59% in the dehydrated ( $.54 \pm .01$  ms) compared to the euhydrated ( $.51 \pm .01$  ms) condition. Although not significant ( $t_9 = 2.257, P = .051$ ), the response direction 2 response time was decreased 5.05% in the dehydrated ( $.63 \pm .08$  ms) compared to the euhydrated ( $.66 \pm .10$  ms) condition. Other non-significant findings revealed that response speed of several subtests increased in the dehydrated condition. Our preliminary findings indicated that response speeds may be impaired when dehydrated thus potentially increasing susceptibility to injury or reducing athletic performance.

### Active Dehydration Impairs Upper And Lower Body Anaerobic Muscular Power

Jones LC, Cleary MA, Lopez RM, Zuri RE: Florida International University, Miami, FL

Data on the effects of active or passive dehydration on muscular power are inconclusive. We examined the effects of active dehydration on upper and lower body anaerobic muscular power. Participants ( $n = 7$ , age =  $27.1 \pm 4.6$  yr, weight =  $86.4 \pm 9.5$  kg) were selected based on upper and lower body resistance training 2 – 3 sessions·wk<sup>-1</sup>. Upper and lower body Wingate anaerobic power tests were performed in a euhydrated (normally hydrated) condition and again following recovery from the heat stress trial (about 1.5 hr of rest in a thermoneutral environment) to attenuate hyperthermia and fatigue. The heat stress trial consisted of treadmill exercise in a hot, humid environment ( $33.1 \pm 3.1$  °C,  $55.1 \pm 8.9\%$  relative humidity) until a  $3.3 \pm 0.2\%$  body mass loss was achieved. Motivation (on a 13 cm visual analog scale) and fatigue severity (on a 9 point Likert scale) were rated prior to both anaerobic power tests. Paired t-tests were performed on each dependent measure. Motivation ratings were not significantly different ( $t_6 = 2.322, P = .059$ ) in the euhydrated and dehydrated conditions; however, motivation was decreased 23.0% in the dehydrated ( $6.8 \pm 3.2$  cm) compared to the euhydrated ( $8.9 \pm 1.5$  cm) condition. Fatigue severity was significantly ( $t_5 = -4.134, P = .009$ ) increased 70.0% in the dehydrated ( $5.0 \pm 2.0$ ) compared

to the euhydrated ( $1.5 \pm .8$ ) condition. Upper body mean power was significantly ( $t_6 = 3.307, P = .016$ ) reduced 7.17% in the dehydrated ( $1195.71 \pm 244.14$  Watts) compared to the euhydrated ( $1406.86 \pm 260.31$  Watts) condition. Lower body mean power was significantly ( $t_6 = 5.071, P = .002$ ) reduced 19.20% in the dehydrated ( $2202.00 \pm 377.04$  Watts) compared to the euhydrated ( $2725.14 \pm 555.56$  Watts) condition. Upper body peak power was significantly ( $t_6 = 2.456, P = .049$ ) reduced 14.48% in the dehydrated ( $1620.00 \pm 258.58$  Watts) compared to the euhydrated ( $1894.29 \pm 346.16$  Watts) condition. Lower body peak power was significantly ( $t_6 = 7.091, P \leq .001$ ) reduced 18.36% in the dehydrated ( $2888.57 \pm 448.07$  Watts) compared to the euhydrated ( $3538.29 \pm 617.79$  Watts) condition. No other significant differences were found. Athletes, coaches, and athletic trainers should be aware that active dehydration of 3.3% body mass negatively impacts upper and lower body anaerobic muscular power. In sports such as American football, anaerobic power is particularly important and impairments as a result of dehydration during exercise in a hot, humid environment may potentially lead to increased susceptibility to injury or reduced athletic performance.

### Assessment of Recovery Rates During Light Exercise Using Micro-Climate Cooling Products

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A number of athletic training camps require routine exposures to extreme temperature conditions. Micro-climate cooling products (cooling vests) have been developed to reduce risk of heat related injuries and illnesses. The objective of this study was to evaluate the effectiveness of using cooling vests during the recovery phase of exercise (returning to pre-exercise conditions) following light exercise in high temperature environments. Eight, fit male participants, ranging in age from 21 to 33 years (mean = 24.25, standard deviation = 3.85) were evaluated. Dependent variables included recovery time (time required for heart rate (HR) and core body temperature ( $T_{co}$ ) to return to pre-exercise levels), HR reductions per minute, and  $T_{co}$  reductions per minute. The independent variable was the recovery test performed. Each participant completed three trials: (1) recovery with no vest (Base), (2) recovery with either the HeatShield (HS) or AirVest (AIR), and (3) exposure with

increased load and recovery with either the HeatShield ( $HS_{load}$ ) or AirVest ( $AIR_{load}$ ). The protocol consisted of continuous walking on a motorized treadmill at 5 km h<sup>-1</sup> and 0% gradient while wearing a standard fire fighters ensemble in an environmentally controlled room (35°C, 40% humidity, and 0.9 m sec<sup>-1</sup> wind speed). Participants acclimated to the room conditions by remaining seated for 20 minutes before beginning exercise. Participants exercised until 1 hour was expended or until reaching safety criteria: 1)  $T_{co}$  reached 39°C, 2) HR reached 85% of individual maximum determined through a GXT, or 3) participant experienced adverse symptomology. Participants were immediately placed in a thermal neutral room and fitted with the appropriate recovery vest following exercise. Variable were analyzed using repeated measures ANOVA and Tukey's multiple comparison tests. Recovery time and  $T_{co}$  were significant by condition ( $p = 0.08$  and  $p = 0.07$ ). Recovery time was shortest  $AIR$  and  $AIR_{load}$  ( $15.65(3.17)$  and  $15.33(3.62)$ ) followed by  $HS$  and  $HS_{load}$  ( $20.41(2.71)$  and  $17.71(2.58)$ ), and the Base condition ( $22.77(2.56)$ ). These findings provide support for the use of cooling vests for recovery of persons following light exercise.  $T_{co}$  reductions were found to reduce to normal levels much faster when any cooling vest was used, and recovery time was shorter when a cooling vest was used. No significant differences in heart rate reductions were found, though a trend was noted and may found to be significant with a larger sample size. Overall, the findings of this project support the use of micro-climate cooling products for persons working in extreme temperature conditions.



## Free Communications, Oral Presentations: Heat and Hydration II

Wednesday, June 16, 2004, 1:00PM-3:00PM, Room 338; Moderator: Gary Dorshimer, MD

### The Incidence Of Heat Illness In Football At Five Southeastern Universities

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Athletic trainers must consider environmental conditions when making decisions concerning football practices. Those working in southern settings are faced with stressful environmental conditions often associated with the late summer and early fall. Strategies to minimize heat stress include proper acclimatization, hydration, conditioning, heat illness recognition, and weather monitoring. The purpose of this project was to evaluate the rate of exertional heat illness during a three month period (August-October) at five southeastern universities. The Heat Stroke Checker (KEM Kyoto Electronics Manufacturing Ltd; Japan) measured environmental conditions three times a day at each location. The American College of Sports Medicine (ACSM) and Department of Defense (DOD) Wet Bulb Globe Temperature (WBGT) Index Risk Charts identified the levels of heat injury risk. Heat cramps, heat syncope, heat exhaustion, heat stroke, and hyponatremia were evaluated based on the NATA Exertional Heat Illness position statement. A reportable injury was any athlete who incurred a heat related illness evaluated by the medical staff. A total of 139 heat-illnesses were reported with an injury rate was 4.19/1000 athlete-exposures (AE) during the three-month period. No cases of heat stroke or hyponatremia were reported. Evaluating each month individually, the greatest number of injuries occurred during August (88%) with an injury rate of 8.95/1000 AE. During August, the injury rate was 6.31/1000 AE for heat cramps, 2.06/1000 AE for heat exhaustion and 0.58/1000 AE for heat syncope. Pearson correlations between the ACSM and DOD Index Risk Charts and specific heat injuries showed no statistically significant relationships ( $p>.05$ ). Our study demonstrated a higher heat exhaustion injury rate compared to the NCAA surveillance data possibly associated to differences in injury definitions. The incidence of heat illness in the months of September and October decreased dramatically, suggesting football athletes are at greatest risk of heat illness during August. Our data suggests that during the late

summer, previously reported guidelines may overstate the risk of heat illness in highly trained football athletes practicing with the southeastern United States. The development of regionally specific heat index guidelines is recommended.

### Blood, Urine And Body Weight Measures Of Hydration Status In NFL Players Exposed To An Aggressive Hydration Program During Preseason Training

Fowkes Godek S, Sugarman E, Burkholder R, Dorshimer G: West Chester University, West Chester, PA; Philadelphia Eagles, Philadelphia, PA; and Delancey Medical Associates, Philadelphia, PA

Minimizing the risk of heat-related disorders is a primary goal of ATC's who provide healthcare to football players during preseason two-a-day training. It is a common belief that the prevention of dehydration accomplishes this goal therefore, aggressive hydration protocols are optimal. The purpose of this field study was to measure plasma volume and body weight changes, and urine indexes during the first week of two-a-day preseason training in professional football players exposed to an intrusive hydration protocol. Six veteran NFL players age=28.33 $\pm$ 3.56, ht=188.4 $\pm$ 6.3cm, wt=109.4 $\pm$ 22kg and BSA=2.35  $\pm$ .24m<sup>2</sup>, representing defensive backs (n=2), linebackers (n=1), tight ends (n=1) offensive (n=1) and defensive (n=1) linemen participated. Baseline (BL) body weight (BW), blood and urine samples were obtained upon arrival to camp and then before and after every practice on Days 2, 3, 4 and 6 of preseason training. Players did physical testing on Day 1, practiced two times per day on Days 2, 3, 4 and 6 and once on Day 5. Full pads were worn in the morning and shells were worn in the afternoon. Plasma volume (PV) changes were calculated from hematocrit and hemoglobin, urine samples were analyzed for specific gravity (USG) by a refractometer and sodium (UNa+) and potassium (UK+) by ion-selective electrodes. Percent dehydration (%Dehy) was calculated from change in BW from BL measures. PV was assessed for changes during practices and from BL measures through Day 6. Data was analyzed using one-way ANOVA with repeated measures. Average wet bulb temperatures were

68.7 $\pm$ 4.3°F for AM and 74 $\pm$ 6.7°F for PM practices. PV was contracted (-8%) after practices on Day 2 and was significantly different from the mild expansion seen on Days 3 (+1.8%) and 6 (+1.6%). A significant linear trend was found for PV over time. PV was below BL (-1.8%) pre-AM practice on Day 2 but expanded to a high of 14.3% above BL post-PM practice on day 4,  $p<0.01$ . Compared to BL, subjects were significantly dehydrated at the following time periods: post-AM and post-PM on Day 2 and post-AM on Days 3 and 6,  $p<0.05$ . Pooled data from all 4 days indicated %Dehy pre-AM (-0.85 $\pm$ 0.17%), post-AM (-1.8 $\pm$ 0.21%), pre-PM (-0.93 $\pm$ 0.16%) and post-PM (-1.67 $\pm$ 0.21%) were different from BL,  $p<0.0001$ . USG on Days 2-6 were higher than BL pre-AM (1.0225 $\pm$ 0.0016), post-AM (1.0283 $\pm$ 0.0019) and post-PM (1.0299 $\pm$ 0.0019) practices,  $p<0.001$ . UNa+ dropped from 140.1 $\pm$ 15.9 mmol/l at BL to 57.3 $\pm$ 10.9, 54.6 $\pm$ 10.96, 61.99 $\pm$ 14.4 and 57.8 $\pm$ 10.8 mmol/l on Days 2, 3, 4 and 6 respectively, all  $p<0.01$ . UK was higher on Day 6 (69.2 $\pm$ 5.3mmol/l) compared to BL (45.3 $\pm$ 5.5mmol/l) and Days 2 (39.8 $\pm$ 4.2mmol/l), 3 (42.8 $\pm$ 3.9mmol/l) and 4 (42.5 $\pm$ 3.9mmol/l), all  $p<0.01$ . UK+ was also higher post-AM (53.7 $\pm$ 4.3mmol/l) and post-PM (62.0 $\pm$ 4.5mmol/l) compared to pre-AM (39.7 $\pm$ 4.1mmol/l) and pre-PM (38.85.3 mmol/l). Urine measures and changes in BW and PV indicate that professional football players are chronically dehydrated during the first few days of pre-season two-a-day training. PV expands by Day 3 but urine and BW measures indicate that even with an aggressive hydration protocol, FB players cannot maintain normal BW and fluid balance. NFL players may need dietary sodium supplementation during the first week of preseason training camp. High UK+ excretion post practices may indicate muscle cell damage.

### Core Temperature And Dehydration Status In Division II Collegiate Football Players During Two Different NCAA Mandated Pre-Season Practice Schedules

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The NCAA implemented a five-day acclimatization period for pre-season football practice in 2003. The purpose of this study was to compare core temperatures

(Tc) and percent of dehydration (%Dehy), as determined by weight loss, in college football players participating in pre-season football practice during the summers of 2002 (no five-day acclimatization period) and 2003. Ten football players participated in data collection during the 2002 pre-season. A second group of football players matched by size, position and relative playing time participated in data collection for the 2003 pre-season. Data were collected from each subject on day 4 in 2002 (AM and PM) and 2003 (AM); and AM and PM on day 8 in 2002 and day 10 in 2003. Prior to the first practice session each year baseline (BL) nude body weights (BW) were recorded to the nearest ~ lb for all subjects. On each day of data collection BW was recorded for subjects before and after each practice session. %Dehy was determined by change in BW from BL. On the night before data collection each subject ingested a temperature sensor (Cor Temp Temperature Sensor, HQ, Inc.) which transmits accurate internal temperatures to a hand held recorder allowing for monitoring of Tc. Tc was then measured one hour prior to, at 15-25 min. intervals during, and at the conclusion of practices. Correlated t-tests were used to measure differences between physical characteristics of subjects, Tc and %Dehy. Correlation between the highest Tc recorded and post practice %Dehy was calculated combining data from both years (n=54). The alpha level was set at .05. There were no differences between the physical characteristics of the two groups of subjects (ht=188.0± 4.8 cm and 187.2±5.9 cm; BL=117.1±15.4 kg and 119.5±15.4 kg; body surface area=2.4±0.15 m<sup>2</sup> and 2.4±0.16 m<sup>2</sup> for 2002 and 2003 respectively). There were no differences between the maximum Tc recorded for each subject during the 2002 and 2003 pre-seasons ( Tc = 38.69±0.31°C and 38.88±0.32°C on day 4 AM; 38.35±0.14°C and 38.67±0.27°C for AM of day 8 , 2002 and AM of day 10, 2003 respectively; 38.64±0.24°C and 38.46±0.56°C for PM practice of day 8, 2002 and PM practice of day 10, 2003 respectively). There were no differences between %Dehy measured at any time during the 2002 and 2003 seasons ( %Dehy= -0.42±1.66 and 0.16±.79 for pre-practice AM on day 4; -1.67±1.32 and -1.28 ±0.64 for post-practice AM on day 4; -0.27 ±1.23 and -0.16±.80 for pre-practice AM on day 8, 2002 and day 10, 2003 respectively; -1.38 ± 1.24 and -1.53±1.10 for post-practice AM on day 8, 2002 and day 10, 2003 respectively; -.27 ± 1.20 and -0.57±0.94 for pre-practice PM on day 8, 2002 and day 10, 2003 respectively; -1.74±1.34 and -1.46±1.19 for post-practice PM on day 8, 2002 and day 10, 2003 respectively). No

correlation was found between Tc and %Dehy (r=0.232, p=0.091). NCAA football rule changes for 2003 to include a five-day acclimatization period resulted in no significant differences in Tc or %Dehy compared to 2002. There was no correlation between core temperatures and percentage of dehydration over the two years of data collection. *This study was partially funded by the NCAA.*

### **Hyponatremia In A Male Collegiate Soccer Player**

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During participation in 2002 summer tournament games, a 20 year-old male collegiate soccer player complained of headaches followed by blurred vision, nausea, cramping, vomiting, temporary hypotonia, and periodic loss of consciousness. The athlete was taken to the emergency room on four separate occasions by his parents. Evaluation by the attending physician revealed no mechanism of injury prior to the onset of symptoms, or history of illness or disease. All blood work performed during the initial visits was unremarkable. The athlete was diagnosed with dehydration and instructed to increase his fluid intake. Differential diagnosis included dehydration, heat exhaustion, heat stroke and hyponatremia. Similar evaluation and discharge instructions were given by the emergency room following each episode, with the exception of the fourth episode, in which the attending physician diagnosed him with hyponatremia. The athlete was instructed to begin taking salt tablets daily to decrease the severity of symptoms. Since the final emergency room visit, the athlete continued daily consumption of 3900mg of salt with no symptom reoccurrence. In August 2003 during pre-season conditioning, the athlete reported a reoccurrence of the original symptoms previously experienced. On a daily basis through the pre-season, the athlete removed himself from participation secondary to headaches and lower extremity cramping. Following each episode, the athlete was withheld from full participation until all symptoms subsided. An exercise physiologist with expertise in heat related illness was consulted to conduct an on-site sweat and urine analyses prior to, during and following one-hour of intense exercise. The athlete's pre-activity urinalysis level on the refractometer scale was 1.010 and the post-activity level 1.005 (minimal dehydration level

is 1.010). A sweat rate of 2.3L/hour was measured, this being within normal limits (1-2.5 L/hr). The total sweat fluid loss after activity was 2.3L (1.5% body weight). The post-exercise total sweat sodium concentration was 76.0mmol/L (1747.2mg/L), with normal levels being 35 mmol/L and the final sweat sodium loss rate was approximately 4020mg/hour, with normal levels being approximately 2400mg/hour. Based on these results, it was thought that the athlete was actually drinking too much water prior to the beginning of exercise. After analyzing the sweat and urine samples, recommendations were developed for the athlete to follow during and after sport activity. During activity recommendations were to drink slightly salted Gatorade consisting 1180mg of sodium (approximately half a teaspoon) of non-iodized salt thoroughly mixed with 32 ounces of Gatorade. All additional desired fluid consumption was not to exceed 32 ounces of water per hour. Due to soccer regulations, the athlete was unable to adhere completely to the 'during activity' guidelines. Therefore, his during game routine included consuming 17 ounces of Gatorade mixed with 1180mg sodium at halftime and/or as needed. After activity, the athlete consumed at least 1180mg of sodium mixed with 32 ounces of Gatorade for each hour of activity. At present, symptom severity has decreased. The exact reason for this decrease is unknown, possibly from the hydration guidelines or from different weather conditions. Following the conclusion of the season, the athlete will seek to contact more specialists in order to determine the exact or potential causes which led to his development of hyponatremia. Hyponatremia is an underdiagnosed heat illness in the athletic population. Those cases that are reported most often develop in marathon runners, ultradistance event participants and tri-athletes. Further, symptoms of hyponatremia often develop following four hours or more of activity. Therefore, this finding of hyponatremia in a soccer player with symptom onset with as little as 1 hour of activity is quite rare.

### **A Comparison Of Three Cooling Methods On Core Body Temperature**

Walker SM, Horodyski MB, Powers M, White LJ: University of Florida, Department of Exercise and Sport Science and Department of Orthopaedics and Rehabilitation, Gainesville, FL

The purpose of this study was to compare the influence of three cooling techniques on

core body temperature in individuals while exercising in hot and humid environmental conditions. Hydration status was also observed in these individuals before and after exercise trials. Twelve heat-acclimatized subjects, 9 males and 3 females (Mean  $\pm$  SD age: 22  $\pm$  1.5yrs, height: 178.4  $\pm$  5.5cm, mass: 81.8  $\pm$  13.4kg, and % body fat: 16.9  $\pm$  9%), participated in four trials. Each trial consisted of completing twenty minutes of a standard exercise session, ten minutes of one cooling method or the control, and a second exercise session for twenty minutes. Both exercise sessions included ten minutes of stadium running at 2-minute intervals with 1-minute rest in between and 10 minutes of repeated two 25-yard sprints with 1-minute rest in between. The subjects were encouraged to complete the same amount of stadium steps during each interval and each sprint in the same amount of time to have consistency over the four trials. Cooling time included treatment by one of the three cooling methods or control for the full ten minutes. The subjects were treated by either a cold towel, a fan, cold water immersion (50° to 55° F), or sat upright (control) during the four trials. Dependent measures were core body temperature measured by a telemetric temperature sensor, heart rate, and rate of perceived exertion. Hydration status was measured via weight loss, urine color, and specific gravity. Analysis of variance with repeated measures revealed no significant difference across the four trials on core body temperature or rate of perceived exertion although cold-water immersion had a tendency to result in lower core body temperatures. The changes in core body temperature from pre-immersion to the second minute of the second exercise session, when core body temperatures were the lowest, were .65°, .42°, .38°, and .38° C for cold water immersion, cold towels, fan, and control treatments respectively. Cold-water immersion resulted in a significantly lower heart rate. Core body temperature, heart rate, and rate of perceived exertion significantly increased with exercise, decreased with cooling, and increased with return to exercise during each trial. Significant differences were noted pre and post activity for each hydration status measurement. In conclusion, although no significant differences were found between cooling methods, the data indicates a tendency for cold-water immersion to be superior. This finding warrants further investigation with a longer exercise session and a larger sample size.

### Effects Of A Cooling Vest On Core And Skin Temperature Following A Heat Stress Trial In Healthy Males

Lopez RM, Cleary MA, Zuri RE, Jones LC: Florida International University, Miami, FL

Investigations on modalities for rapidly cooling core body temperature are necessary to provide evidence for the most effective clinical practice in the treatment of exertional heat illnesses. We examined the efficacy of a cooling vest on reduction of body temperature following a heat stress trial. A randomized control design with an experimental ( $n = 5$ ) vest group (V) and a control ( $n = 5$ ) no vest (NV) group was used to study healthy male participants (age = 25.6  $\pm$  1.6 years, weight = 80.3  $\pm$  4.3 kg). All participants completed a heat stress trial consisting of treadmill exercise in a hot, humid environment (33.1  $\pm$  3.1 °C, 55.1  $\pm$  8.9% relative humidity) until a 3.27  $\pm$  .08% body mass loss was achieved. Following the heat stress trial, participants recovered by resting in a thermoneutral environment (26.6  $\pm$  2.2 °C, 55.4  $\pm$  5.8% relative humidity) wearing the ClimaTech® HeatShield™ cooling vest (V) or without the cooling vest (NV) until core (rectal) body temperatures returned to baseline (50.2  $\pm$  17.1 min, range = 28 – 80 min). Core (rectal) and skin (arm) temperature were monitored throughout the heat stress trial and recovery. Independent t-tests and separate 2 (V and NV)  $\times$  2 (heat stress trial and recovery) repeated measures ANOVAs were performed. No significant differences in core body temperature between the V and NV groups were found during the recovery period ( $F_{1,8} = .815$ ,  $P = .393$ , power = .126); however core body temperature for both groups was significantly ( $F_{1,8} = 166.018$ ,  $P \leq .001$ , power = 1.000) decreased 2.6% or 1.0 °C from 0 to 30 min (38.8  $\pm$  0.3 °C and 37.8  $\pm$  0.3 °C, respectively) of the recovery period. Although not significant ( $t_8 = 1.219$ ,  $P = .258$ ), the time for return to baseline core body temperature during the recovery period was 22.6% faster for the V group (43.8  $\pm$  15.1 min) than for the NV group (56.6  $\pm$  18.0 min). No significant ( $F_{1,8} = 5.118$ ,  $P = .054$ , power = .390) difference was found between the V and NV groups in mean arm skin temperature. The cooling vest is a practical adjunctive cooling modality that in our sample did not significantly reduce core body temperature compared to a control group. We recommend using the cooling vest only for treatment of mild symptoms of heat exhaustion and using ice-water immersion

for rapid cooling for the treatment of severe hyperthermia or heat stroke.

### Influence Of 10 Days Of Creatine Loading On Hydration Status

Casa DJ, Fiala KA, Roti MW, D'Alfonso MR, Clements JM, Seen AD, Hile AM, Watson G, Armstrong LE, Maresh CM: University of Connecticut, Storrs, CT

Given recent anecdotal accounts implying an increased incidence of exertional heat illness and compromised hydration when supplementing with creatine, the effects of creatine loading on hydration state are of great interest to athletes, coaches and clinicians. Twelve males (age = 22  $\pm$  1 y, height = 71  $\pm$  1 cm, mass = 78.8  $\pm$  1.2 kg, body fat = 9.1  $\pm$  0.7 %,  $\text{VO}_{2\text{max}} = 50.9 \pm 1.0 \text{ ml kg}^{-1} \text{ min}^{-1}$ ) were supplemented with 21.6 g day<sup>-1</sup> of creatine monohydrate or placebo for 10 days (double-blind, randomized, cross-over design with washout between trials of 48  $\pm$  10 days). Between 7:00 and 8:00 am of days 1, 4, 7, 8, and 10 the subjects reported to the laboratory for body weight, blood and urine samples, and fluid assessment via multiple frequency bioimpedance analyzer. Twenty-four hour urine collections were completed between day 3 and 4 and day 7 and 8. On day 7, subjects performed 200 min of exercise in the heat including 120 min of sub-maximal exercise followed by an 80 min heat tolerance test 12 repetitions of an alternating 3 min walk (6.6  $\pm$  0.3 km h<sup>-1</sup>, 37  $\pm$  5.8 %  $\text{VO}_{2\text{max}}$ ) and 1 min run (19  $\pm$  0.6 km h<sup>-1</sup>, 114.9  $\pm$  5.3 %  $\text{VO}_{2\text{max}}$ ). A significant ( $p < .05$ ) interaction indicated an increase in morning body weights from day 1 to day 10 for the creatine monohydrate trial compared to no increase for the placebo trial. Measures of hydration and electrolyte status (total body water, intracellular body water, extracellular body water, plasma osmolality, plasma sodium, plasma potassium, % change plasma volume, total plasma protein, urine osmolality, urine color, and urine volume) revealed no differences ( $p > .05$ ) between creatine monohydrate and placebo trials across the 10 days. In summary, 10 days of creatine supplementation did not alter hydration status. Additionally, hydration status restoration following an extreme exercise session was not compromised due to creatine supplementation as indicated by no trial differences on the morning of day 8.



## Free Communications, Thematic Posters: Shoulder Rehabilitation

Thursday, June 17, 2004, 1:45PM-3:45PM, Room 338; Moderators: Brad Montgomery, MAT, ATC, and Tim Uhl, PhD, ATC, PT

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### **The Effectiveness Of Proprioceptive Neuromuscular Facilitation (PNF) Exercises On Shoulder Joint Position Sense In Baseball Players**

Kitano I: Plymouth State College, Plymouth, NH

The purpose of this study was to determine if shoulder joint position sense (JPS) before and after a throwing bout could be improved with a 6-week Proprioceptive Neuromuscular Facilitation (PNF) intervention for collegiate baseball players. A total of 12 subjects (age =  $21.25 \pm 1.22$  years, height =  $184.15 \pm 5.5$  cm, weight =  $88.94 \pm 11.7$  kg) were randomly placed into the control or PNF intervention group. The subjects in PNF intervention group performed PNF diagonal 1 (D1) and 2 (D2) pattern exercises of the upper extremity with maximal repeated exercises three times per week for six weeks. Shoulder JPS was measured at two reference angles, at  $10^\circ$  from full external rotation (ER) and  $60^\circ$  of internal rotation (IR), as shoulder proprioception through active reproduction of active positioning (ARAP) with a Kinesthesiometer (Lafayette Instrument Co, Lafayette, IN). Analysis of Variance for shoulder JPS revealed no significant difference for shoulder JPS between PNF intervention and control groups across testing day and testing conditions. No significant interaction was found for treatment intervention groups by testing days by testing conditions. Additionally, no significant ( $p > .05$ ) main effects were found for treatment intervention groups across testing days and conditions. Improving shoulder JPS through long term PNF exercise training in overhead throwing athletes is still unclear. Further research is needed to determine the effectiveness of PNF exercises to enhance proprioceptive abilities of the shoulder in collegiate baseball players.

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### **The Effect Of A Six Week Shoulder Strengthening Program On The Muscular Activity Of The Trapezius, Posterior Deltoid, And Infraspinatus Muscles**

Van Lunen BL, Allyn SB, Walker ML, Tamburello M: Old Dominion University, Norfolk, VA

The endurance of the rotator cuff and other shoulder musculature is crucial in the rehabilitation of shoulder injuries, however the measurement of endurance over time has not been thoroughly evaluated. The purpose of this study was to determine the effect of a six week shoulder strengthening program on the electromyography (EMG) activity and force of various shoulder musculature. Thirty (15 males: age =  $22.27 \pm 1.58$  yrs, ht =  $184.23 \pm 5.50$  cm, mass =  $82.46 \pm 5.20$  kg; 15 females: age =  $22.4 \pm 0.99$  yrs, ht =  $168.80 \pm 4.98$  cm, mass =  $58.85 \pm 7.60$  kg) physically active people completed four surgical tubing exercises (standing lateral rotation, prone external rotation, tubing fencing, standing D2 flexion) with their nondominant arm every other day over a six week period. The six-week program initially consisted of 3 sets of 10 repetitions and was increased every two weeks by 5 repetitions per set. The testing protocol involved 20 repetitions of external rotation in a seated position with the shoulder in scaption and  $90^\circ$  degrees of abduction, and elbow flexed to  $90^\circ$ . Surface electrodes were positioned over the upper trapezius, posterior deltoid, and infraspinatus muscles on the subject's dominant and non-dominant arm. Muscle activity was recorded while the subject's performed maximal voluntary isometric contractions (MVIC) for each muscle and during the first and twentieth repetition of the testing exercise. A hand held dynamometer was used to assess the force during the MVICs for each muscle. Resistance for the tubing protocol was then assigned to the subject's as a percentage of the maximal resistance length of the tubing as related to the weight used for the testing protocol. Repeated measures ANOVA's were used to determine the effects of the strengthening protocol on the EMG values (muscle activity and mean frequency slope) and force of the muscles over time. Muscle activity increased over time with the posterior deltoid generating the greatest activity. The median frequency of the infraspinatus

increased at the 20<sup>th</sup> repetition following the strengthening protocol ( $p=.001$ ). There was also an increase in the muscle force over time ( $p=.02$ ) with the nondominant shoulder musculature reaching the force output of the dominant shoulder. The endurance of the infraspinatus increased over time and through the 20 repetitions by demonstrating greater activity. Future research should examine the number of repetitions that can be completed effectively following an endurance protocol.

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### **The Effect Of Exercise Sequence On Muscular Activity In Selected Rotator Cuff Muscles**

Fraser CR, Bradshaw AE, Van Lunen BL, Tamburello M, Walker ML: Old Dominion University, Norfolk, VA

Several rehabilitation regimens advocate a unique sequence of exercises as a more efficient or effective means of activating the target musculature. The purpose of this experiment was to determine the effect that sequence of exercises has on selected rotator cuff musculature as measured by electromyography (EMG). Twenty (10 females, 10 males) collegiate athletes volunteered to participate in our study. All were members of an overhead athletic team and had no history of shoulder pathology for three months. Testing was performed on the dominant shoulder for each of the two testing sessions. During each testing session surface electrodes were placed over the infraspinatus and teres minor muscles, and a fine-wire electrode was inserted into the supraspinatus muscle. Maximum voluntary isometric contraction (MVIC) was then performed for each of the three muscles (Kendall's positioning). The subject was then familiarized with the cadence and proper form of the exercises included in the protocol. The original protocol consisted of the lateral arm raise, supraspinatus shoulder raise and the forward shoulder flexion that were performed standing with an erect posture using a 1-pound dumbbell in sets of 30 repetitions. The hitchhiker, high elbow and external rotation, and superman exercises were performed prone on a table using a 3-pound dumbbell in three sets of 10 repetitions. Finally, the wall push up was performed standing three feet from the base of the wall for one set of 25 repetitions. Each

subject completed both the original exercise sequence and one of the random sequence assignments. EMG values for each exercise were recorded during the 3<sup>rd</sup> and 7<sup>th</sup> repetitions of each set. The recorded values were expressed as a percent of the corresponding MVIC for each muscle during the sequence. A 3x2x7 repeated measures ANOVA was used for data analysis to show significant differences ( $p < .05$ ). Main effects were present for muscle ( $p = .001$ ) and for exercise ( $p = .000$ ). An interaction was found between muscle and exercise ( $p = .000$ ), however no interaction ( $p = .366$ ) was found with the addition of sequence. Although not statistically significant, a notably higher trend in muscle activity was found in the exercises during the random sequences. The sequence of the suggested exercises does not positively affect muscular activity in selected rotator cuff muscles. Future research should examine whether muscular activity increases following a training program using both this designed protocol sequence and random sequences of the same exercises.

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### **Power Output And Pain Perception Of Three Common Rehabilitation Exercises For The Supraspinatus Muscle**

Hann MJ, Caswell SV, Deivert RG: Ohio University, Athens, OH

The supraspinatus muscle serves a major role in stabilizing the humeral head within the glenoid fossa. Hence, impingement syndrome and other injuries can occur when the supraspinatus muscle becomes weakened. Therefore, supraspinatus muscle strength is an important component in both the prevention and rehabilitation of injuries to the shoulder. This study investigated whether differences exist in the power output and perceived pain of subjects performing three common strengthening exercises targeting the supraspinatus muscle. Fifty college age subjects ( $M = 23$ ,  $F = 27$ ) with no prior history of shoulder injury performed 10 repetitions of each the full-can, the empty-can, and the prone horizontal abduction exercises. Power output and a perceived pain were recorded for each exercise. Average peak power output was measured in watts using the Dynatrac isotonic dynamometer manufactured by Baltimore Therapeutic Equipment. Each subjects' self-reported perceived discomfort was measured using a visual analog pain scale at the completion of each exercise session. The research design of the study was two separate one-way between

subjects ANOVAs with  $\alpha = .05$ . Data analysis revealed significant main effects for exercise type and the dependent variables of average peak power output ( $F_{2,147} = 13.267$ ,  $P < .001$ ,  $h_2 = .15$ ) and perceived pain ( $F_{2,147} = 11.774$ ,  $P < .001$ ,  $h_2 = .13$ ) respectively. Post-hoc analysis utilizing Tukey's HSD indicated that average peak power output for the prone horizontal abduction exercise ( $M = 61.9$ ) was significantly less than that of both the empty-can ( $M = 94.5$ ) and full-can ( $M = 96.4$ ) exercises. Further analysis using Tukey's HSD also revealed that subjects reported perceiving significantly less pain during the full can exercise ( $M = 2.2$ ) than perceived during the empty can ( $M = 6.2$ ) and prone horizontal abduction ( $M = 8.1$ ) exercises. The clinical implications of these findings suggest that ATC's should be cautious when advocating the use of prone horizontal abduction exercises in the early stages of shoulder joint rehabilitation. Rather, our findings demonstrated the full-can exercise to produce the greatest average peak power output with minimal perceived pain, therefore we advocate incorporating full-can exercises early into the shoulder rehabilitation program. The empty-can and prone horizontal abduction exercise results demonstrated decreased power output coupled with a greater perceived pain. This finding appears to support the use of these exercises in the later stages of a shoulder rehabilitation program.

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### **The Acute Effect Of Faults' Modified Passive Stretching Routine On Shoulder Range Of Motion In Collegiate Baseball Players**

August AM, Sauters EL: Department of Sports Health Care, Arizona School of Health Sciences, Mesa, AZ

Prophylactic stretching of the shoulder complex of competitive baseball players is frequently recommended to reduce the incidence of shoulder injury. To date, very little quantitative data are available from which to evaluate the efficacy of various stretching techniques. Therefore, the purpose of this study was to evaluate the acute effects of Faults' modified passive stretching routine on shoulder range of motion in collegiate baseball athletes. Shoulder range of motion measurements were taken in thirty collegiate baseball players ( $20.2 \pm 1.2$  years,  $184.9 \pm 6.1$  cm,  $84.9 \pm 9.2$  kg) unimpaired shoulders immediately before and after receiving a series of 12 passive stretches to the throwing

shoulder. The throwing and non-throwing shoulders of each athlete were measured for the following dependent variables: 1) shoulder complex internal and external rotation, 2) isolated glenohumeral joint internal and external rotation, and 3) posterior shoulder tightness (cross-body horizontal adduction). Separate repeated measures ANOVAs were performed to examine each of the dependent variables. Within subject variables included Shoulder [experimental (throwing) and control (non-throwing)] and Time (pre- and post-treatment). Significant ( $p < .05$ ) main effects for Shoulder and Time and significant ( $p < .05$ ) Time x Shoulder interactions were observed for shoulder complex and glenohumeral external rotation. The experimental shoulder gained an average of  $7.6^\circ$  of shoulder complex and  $5.3^\circ$  of glenohumeral external rotation following treatment compared to the control shoulder which changed  $< 0.6^\circ$  for both measures. Significant ( $p < .05$ ) main effects for Time and significant ( $p < .05$ ) Time x Shoulder interactions were observed for shoulder complex and glenohumeral internal rotation. The main effect for Shoulder was not significant ( $p = .16$ ) for shoulder complex internal rotation, but was significant ( $p = .001$ ) for glenohumeral internal rotation. The experimental shoulder gained an average of  $9.2^\circ$  of shoulder complex and  $6.4^\circ$  of glenohumeral internal rotation following treatment compared to the control shoulder which changed  $< 1.6^\circ$  for both measures. A significant ( $p < .05$ ) main effect for Time and a significant ( $p < .05$ ) Time x Shoulder interaction were observed for posterior shoulder tightness with no significant ( $p = .29$ ) main effect for Shoulder. Posterior shoulder tightness in the experimental shoulder decreased an average of 2.0 cm following treatment compared to the control shoulder which changed  $< 0.1$  cm. The findings of this study indicate that the Faults' modified passive shoulder stretching routine is effective at producing significant acute increases in shoulder complex and glenohumeral joint external and internal rotation range of motion and posterior shoulder mobility in collegiate baseball players.



### **An EMG Analysis Of Rubber Tubing Resistance Exercises For Throwing Athletes**

Myers JB, Pasquale MR, Laudner KG, Sell TC, Lephart SM: Neuromuscular Research Laboratory, Sports Medicine and Nutrition, School of Health and Rehabilitation Sciences, University of Pittsburgh, Pittsburgh, PA

Throwing athletes, predominantly pitchers, commonly use various rubber tubing resistance programs in the bullpen, dugout, or sidelines to strengthen the shoulder muscles and assist with warm-up prior to throwing. Yet, no research to date has described such programs (i.e. what muscles are being activated or which exercises are most effective). The purpose of this study is to use electromyography (EMG) to describe and rank the effectiveness of 12 rubber tubing resistance exercises commonly utilized by throwers, in activating the shoulders muscles important for throwing. Fifteen male subjects (age:  $24.53 \pm 2.77$  yrs, height:  $1.77 \pm 0.08$  m, mass:  $78.31 \pm 8.20$  kg) with no history of shoulder injury, randomly performed 12 rubber tubing resistance exercises (10 repetitions) including internal and external humeral rotation at  $0^\circ$  and  $90^\circ$  (IR0, IR90, ER0, ER90) of abduction, high, middle, and low scapular rows (HRow, MRow, LRow), punches (Pun), humeral flexion (Flx) and extension (Ext), and stimulated acceleration (Accl) and deceleration (Decl) phases of the throwing motion. Muscle activation of the supraspinatus, infraspinatus, subscapularis, teres minor, pectoralis major, biceps brachii, triceps brachii, anterior deltoid, middle deltoid, latissimus dorsi, serratus anterior, rhomboids, and lower trapezius was assessed with a combination of indwelling-finewire and surface EMG. Mean activation (normalized to a maximum voluntary contraction) of each muscle was calculated during both the increasing and decreasing force phases of each exercise (delineated by a tension load cell) and the overall activation of the exercise. The overall activation during each exercise was used to rank the 12 exercises from highest to lowest (12 to 1) according to the level of activation for each muscle. The rankings given to each exercise for each muscle, were summed to establish an overall ranking for the exercise. Based on the summed rankings, ER90 obtained the highest rank (ranking = 112) followed by Decl (110), Flx (110), Ext (98), HRow (89), Accl (88), Pun (83), LRow (79), MRow (68), IR90 (66), IR0 (56), and ER0 (55). Based on the EMG

analyses and ranking of the exercises, performance of seven exercises (ER90, Decl, Flx, Ext, HRow, Accl, and Pun) resulted in the most activation of all muscles tested. With these seven exercises, moderate activation ( $> 20\%$  MVC) was present in each muscle of the rotator cuff, primary humeral mover, and scapular stabilizer muscle groups. These results suggest that throwing athletes should perform at least these seven exercises during warm up and strength training programs that utilize rubber tubing resistance.

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### **The Acute Effectiveness Of PNF Stretching And Joint Mobilizations For Increasing Posterior Shoulder Mobility Of The Professional Baseball Player**

Goldman BR, Sauers EL: Arizona School of Health Sciences, Mesa, AZ

Posterior shoulder tightness has been implicated as a causative factor for developing internal impingement and SLAP lesions in overhead throwing athletes. Treatments to increase posterior shoulder mobility have been advocated for these athletes, but little evidence exists that quantifies common treatment efficacies. Therefore, the purpose of this study was to examine the acute effectiveness of PNF internal rotation stretching and posterior glenohumeral joint mobilizations for increasing posterior shoulder mobility of the professional baseball player. An experimental intervention design was utilized to evaluate thirty-one professional baseball players (sixteen pitchers and fifteen position players,  $21.9 \pm 2.8$  years,  $188.7 \pm 5.6$  cm,  $88.7 \pm 7.6$  kg) with no current symptoms or previous history of shoulder pathology. For each subject the throwing arm served as the experimental shoulder and the non-throwing shoulder served as an internal control. Measurements of passive isolated glenohumeral joint internal rotation ROM and posterior shoulder tightness were obtained for each subject. Subjects were randomly assigned to one of two treatment groups: 1 = PNF (N = 16); 2 = Joint Mobilization (N = 15). Each subject was then assigned to receive; 1) PNF = 3 sets of PNF hold-relax internal rotation stretching, or 2) Joint Mobilization = 3 sets of grade III and IV posterior glenohumeral joint mobilizations. The two measurements of posterior shoulder mobility were then immediately re-taken. Separate repeated measures ANOVAs were performed for the dependent variables of passive isolated glenohumeral joint internal

rotation and posterior shoulder tightness. Significant main effects for internal rotation ROM were observed for Time (pre- and post-treatment,  $p = .000$ ) and Shoulder (experimental and control,  $p = .001$ ). In addition, a significant Time x Shoulder interaction was observed ( $p = .0001$ ). However, no significant difference between Treatments (PNF and Joint Mobilization) was observed (Time x Treatment =  $p = .133$ ; Shoulder x Treatment =  $p = .258$ ). Significant main effects for posterior shoulder tightness were also observed for Time ( $p = .000$ ) and Shoulder ( $p = .02$ ) and for the interaction of Time x Shoulder ( $p = .000$ ). Similarly, no significant differences were observed between Treatments (Time x Treatment =  $p = .859$ ; Shoulder x Treatment =  $p = .575$ ). These data demonstrate that 3 sets of PNF hold-relax internal rotation stretching or posterior glenohumeral joint mobilizations are equally effective at producing acute increases posterior shoulder mobility in the throwing shoulder of the professional baseball player. Both treatments resulted in an acute increase in passive isolated glenohumeral joint internal rotation and a decrease in posterior shoulder tightness.

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### **Diagonal 2 Training Increases Strength But Does Not Effect Joint Position Sense In Healthy Females**

Dillon M, Piland SG, Broglio SP, Bunn KJ, Dew M, Ferrara MS: University of Georgia, Athens, GA, and St. Mary's Hospital, Athens, GA

Diagonal 2 flexion and extension (D2) tubing exercises are commonly used in the clinical setting and are often thought to improve both strength and joint reposition sense. The purpose of this study was to determine if an eight week resistance tubing training protocol performed in D2 improves strength and joint reposition sense throughout the pattern. Female college aged students (N=36) with no recent involvement in overhead sporting activities were randomly assigned to one of two groups (Training and Control). Measures of dominant arm joint position sense and isokinetic strength in the D2 pattern were performed using a Cybex isokinetic dynamometer. Each group was tested at three time points during the 8-week duration of the study (baseline, week four and week eight). Joint position sense values at three positions in the range of motion, peak torque (flexion and extension), and work (flexion and extension) were collected at

each testing session. The training group completed an exercise program involving the use of resistive tubing in the D2 motion 3 times a week for 8 weeks. Four subjects withdrew from the training group prior to the completion of the study. Final sample sizes were  $n=14$  and  $n=18$  for the training and control groups respectively. Each independent variable was analyzed with a mixed model  $2 \times 3$  (group  $\times$  time) repeated measures analysis of variance (ANOVA). Greenhouse-Geisser method was applied when violations to the assumption of sphericity were committed. Independent samples  $t$ -tests were utilized for the post-hoc analysis of significant main effects. Levene's technique was employed for violations of equality of variances. Alpha was set *a priori* at .05. ANOVA results demonstrated significant main effects for Peak Torque Flexion ( $F_{1,61,48.35} = 6.51$ ,  $p=.005$ ,  $h^2 = .18$ ), Work Flexion ( $F_{2,60} = 5.11$ ,  $p=.009$ ,  $h^2 = .15$ ), and Work Extension ( $F_{1,46,43.82} = 4.81$ ,  $p=.033$ ,  $h^2 = .12$ ) in the D2 flexion and extension pattern. Post-hoc analysis showed a statistically significant difference ( $p \leq .05$ ) between groups at the conclusion of the eight week training period for peak torque flexion, work flexion, and work extension. Analyses of joint position sense variables were non-significant ( $p > .05$ ). Our data indicate that an 8-week D2 specific exercise protocol has beneficial effects for strength, but no effects on joint reposition sense in females.

#### Joint Position Sense Of Loaded And Unloaded Active Shoulder Internal Rotation Movements

Brindle TJ, Uhl TL, Nitz AJ, Shapiro R: Biodynamics Laboratory, University of Kentucky, Lexington, KY

Joint position sense (JPS) is the ability to reposition one's limb in space and is commonly used to measure shoulder proprioception. JPS is typically tested passively, however, active movements could be better indicators of function. Receptors that contribute to JPS include muscle spindles, joint, and cutaneous receptors. Golgi-tendon organs can influence JPS as forces vary with movement. The purpose of this study was to determine if added loads can influence active shoulder JPS, with two common measures of repositioning accuracy; constant error (CE) and variable error (VE). Twenty right side dominant subjects (10 males, 10 females) between the ages of 18 and 35 were screened to ensure no history

of shoulder pathology. Subjects internally rotated their arm to a target angle ( $27^\circ$ ) in a custom made shoulder wheel, at a natural or comfortable speed, with either visual feedback (VF) provided by a video monitor or kinesthetic feedback (KF) provided by passive positioning prior to movement trial. Subjects performed eight VF and KF movements with and without an added load (5% of bodyweight). High-speed motion analysis recorded peak movement velocity of the shoulder wheel apparatus and helped determine final position. JPS was measured as CE and VE of final position relative to target angle. An ANOVA with repeated measures was used to evaluate peak velocity, CE and VE. Evaluation of JPS with CE values indicated no significant difference between loaded and unloaded movements [ $F(1,19)=.27$ ,  $p=.61$ ] but greater CE [ $F(1,19)=23.7$ ,  $p<.001$ ] was noted with KF ( $3.8^\circ \pm .9^\circ$ ) versus VF ( $-.2^\circ \pm 0.1^\circ$ ) movements. VE was significantly larger [ $F(1,19)=11.15$ ,  $p=.003$ ] for unloaded movements ( $2.0^\circ \pm 0.2^\circ$  vs  $1.5^\circ \pm 0.2^\circ$ ) and for KF movements [ $F(1,19)=82.4$ ,  $p<.01$ ]. VE for KF movements was  $2.8^\circ \pm 0.2^\circ$ , and  $0.70^\circ \pm 0.1^\circ$  for VF movements. Peak velocity was greater ( $p<0.05$ ) for movements with KF ( $45.6 \pm 2.9^\circ/\text{sec}$ ) versus VF ( $39.1 \pm 2.1^\circ/\text{sec}$ ) and for unloaded ( $47.8 \pm 3.6^\circ/\text{sec}$ ) versus loaded ( $36.9 \pm 1.0^\circ/\text{sec}$ ) movements. Quantifying JPS can vary depending on the measure employed. Adding small loads to active movement's decreases movement velocity and variability (VE) associated with JPS, but not the CE. Movements that use KF tend to be faster and less accurate than movements with VF. Further study is needed to determine the influence of load on kinesthetic ability. Resistance during proprioception training is necessary to account clinically for the differences observed here.

#### Eccentric And Concentric Ratios For Peak Torque And Total Work Of The Shoulder Rotators

Dale RB, Ogletree T: The University of South Alabama, Mobile, AL, and Thomas Medical Center Physical Therapy, Daphne, AL

Rotator cuff strength (peak torque) and endurance (total work) are important for glenohumeral stability during overhead throwing motions. Many studies have quantified peak torque (PT) of the shoulder rotators but few studies have measured eccentric and concentric muscle

performance with respect to TW production. The purpose of this study was to quantify and compare shoulder internal (IR) and external rotation (ER) muscle performance during eccentric and concentric isokinetic testing of the dominant and nondominant extremities in high school baseball players. The subjects were 19 high school baseball players and informed, guardian-signed consent was obtained prior to their participation in the study. Prior to testing, subjects performed a 5 minute upper extremity warm-up at 60 revolutions per minute. Subjects were tested in a gravity-corrected sitting position with  $90^\circ$  of elbow flexion and shoulder abduction on a Biodex System 3 isokinetic dynamometer (Biodex, Shirley, NY). Subjects performed 20 maximum effort concentric repetitions for IR and ER at 300 degrees per second, which was followed by 4 minutes of rest. Following the rest period, 20 maximum effort eccentric repetitions of the IR and ER were performed. This was repeated on the opposite extremity. The extremity testing order was randomized between subjects. Ratios were calculated for muscle group performance (ER divided by IR) within each mode of action. Data were analyzed with a 2 (mode) by 2 (extremity) ANOVA. There was not a significant main effect for extremity in PT or TW, nor was there an effect for mode with PT. However, the main effect of mode was significant ( $p \leq 0.01$ ) with TW. TW ratios were  $0.75 \pm 0.07$  and  $0.54 \pm 0.03$  for concentric and eccentric modes, respectively ( $p \leq 0.01$ , power = .77). This was due to a large discrepancy between ER and IR TW production during eccentric testing. This discrepancy was associated with a larger relative concentric to eccentric TW improvement in IR (eccentric TW was  $2.6 \pm 0.2$  times concentric TW) compared to the ER (eccentric TW was  $1.9 \pm 0.2$  times concentric TW) muscle group ( $p<0.05$ ). These data present implications for conditioning and rehabilitation of the rotator cuff musculature.

## Free Communications, Oral Presentations: Youth Injuries and Biomechanics

Friday, June 18, 2004, 9:00AM-11:15AM, Room 338; Moderator: Erik Swartz, PhD, ATC

### High School Sports Injury Patterns Among Girl Athletes

Rauh MJ, Macera CA, Ji M: Rocky Mountain University of Health Professions, Provo, UT, and San Diego State University, San Diego, CA

In the past two decades, the participation of girls competing in interscholastic sports has risen at a greater rate than boys. With increased participation in sports, the number of girl athletes at risk for injuries has also increased. While injury patterns of high school boys' sports are well documented, information describing injury patterns among girls' high school sports is limited. The purpose of this study was to describe patterns of new and re-injury among five girls' high school sports. The NATA 1995-1997 High School Injury Surveillance database was used to explore the injury experience of girls participating in the following varsity sports: basketball, field hockey, soccer, softball, and volleyball. The definition of injury required a certified athletic trainer evaluate the injured player and subsequently restricted her from participation. Injuries were separated into new and re-injury categories. Three severity injury classifications were used: minor ( $<8$  days lost); moderate (8-21 days lost); and major ( $>21$  days lost). Incidence rate ratios and 95% confidence intervals (CI) were used to compare injury rates. Overall, 5640 injuries occurred among 4696 players for a case rate of 3.8 injuries/1000 athletic exposures [AEs] and a game/practice ratio of 1.8 (95% CI = 1.7-1.9). Most injuries occurred among soccer players ( $n=1771$  injuries) for a case rate of 5.3 injuries/1000 AEs, and almost 4 times as many soccer-related injuries occurred during games than practices (Game/Practice ratio = 3.7 (95% CI = 3.4-4.1)). The lowest case rate was found among volleyball players (1.9 injuries/1000 AEs) with more injuries occurring during practices than games (Game/Practice ratio = 0.3, 95% CI = 0.1-0.6). The most common types of injuries were sprains, followed by strains and general trauma. When adjusted for practice and game exposures, sprains, fractures, general and neurotrauma-related injuries had significantly higher game than practice injury rates ( $p<.05$ ). About 11% ( $n=638$ ) of all injuries were re-injuries. Most injuries were minor (74%) with no statistically significant differences in severity level

found between new injuries and re-injuries ( $p=.08$ ). Overall, most re-injuries occurred at the lower extremity (74.1%), mostly at the ankle (27.6%) and knee (22.9%). For upper extremity, the shoulder (8.6%) had the highest proportion of re-injury, primarily among softball and volleyball players. This analysis demonstrates that in these five girls' sports, girls are at greater risk for injury during games, especially those considered acute-traumatic. As severity of re-injuries was similar to new injuries, the impact of re-injury needs further exploration. Supported by a grant from the NATA Research & Education Foundation.

### Neuromuscular Coordination And Dynamic Restraint In Children Of Varying Skill Levels

Hamstra KL, Swanik CB, Sitler MR, Ridenour M, Ferber R, Swanik KA, Huxel K: Biokinetics Research Laboratory, Athletic Training Division, Temple University, Philadelphia, PA, and School of HPELS, Athletic Training Division, University of Northern Iowa, Cedar Falls, IA

Inadequate motor skills and dynamic restraint capabilities have been implicated as risk factors that predispose females to non-contact injuries. Research has failed to identify whether these inequalities are innate or result from the lack of accumulated experience and skill development during childhood. The purpose of this study was to assess neuromuscular coordination through examination motor skill, lower extremity dynamic restraint, and sport experience in pre-pubescent females and males. Nineteen female children (mean age= $112.8 \pm 8.5$  months, height= $135.6 \pm 6.2$  cm, and mass= $33.3 \pm 7.8$  kg) and 17 male children (mean age= $106.7 \pm 7.3$  months, height= $132.3 \pm 6.6$  cm, and mass= $30.8 \pm 6.3$  kg) participated in the study. The independent variables were gender and skill level. Motor skill was assessed through analysis of 12 valid and reliable fundamental motor skills. Sport experience was quantified by hours per week and total years in organized and non-organized athletics. The neuromuscular dependent variables were isometric strength (quadriceps, hamstring, hamstring-to-quadriceps ratio), preparatory EMG activity (quadriceps, hamstring,

and hamstring-quadriceps coactivation), and vertical leg stiffness. Participants performed three landing trials from a 24-cm drop height to measure preparatory (mV/s) EMG and vertical leg stiffness (kN/m). Data were analyzed using multivariate (MANOVAs, multiple regression) and univariate (ANOVAs) statistics. A 2 (gender) x 2 (skill level) ANOVA revealed no significant gender differences, but low skilled participants had significantly ( $p<.05$ ) greater (48%) hamstring-quadriceps preparatory muscle coactivation area than high skilled participants. A linear stepwise multiple regression identified that participation in organized sport and hours per week in non-organized sport accounted for 29% of the variance in locomotor skill. No significant gender or skill differences were found in isometric quadriceps strength ( $p=.725$ ), hamstring strength ( $p=.870$ ), hamstring-to-quadriceps ratio ( $p=.870$ ), or vertical leg stiffness ( $p=.383$ ). Adult gender differences in dynamic restraint do not appear evident in the pre-pubescent population, but the influence of skill and experience on neuromuscular coordination is apparent at a young age. The neuromuscular coordination differences that predispose female adults to non-contact anterior cruciate ligament injury may exist as a function of skill rather than innate gender disparities. Skill level appears partially determined by experience in sport, with both decreased skill and neuromuscular coordination compromising dynamic restraint. The skill level disparity in hamstring-quadriceps coactivation suggests less advanced feedforward, or preparatory mechanisms in the low skilled group due to incomplete nervous system maturation or decreased sport experience. Female and male neuromuscular differences may develop during the period of time pre- to post-puberty due to the combined effects of maturation and sport experience.



### Lower Extremity Motion Patterns And Peak Vertical Ground Reaction Force In Male And Female Youth Soccer Players Performing A Jump-Landing Task

Oñate JA, Guskiewicz KM, Yu B, McClure B, Garrett WE, Belez AL: Old Dominion University, Norfolk, VA, and University of North Carolina at Chapel Hill, Chapel Hill, NC

Several investigators have reported that there is a gender disparity in anterior cruciate ligament (ACL) injuries between male and female soccer players, yet minimal data exists in comparing lower extremity motion patterns between gender when performing the stop-jump phase of a jump-landing movement task. Investigators believe that there may be a link relating peak vertical ground reaction force (PVGRF) and ACL injury. The purposes of this study were to determine the influence of lower extremity kinetics and kinematics on PVGRF and if gender differences exist for PVGRF during the stop-jump phase of a jump-landing task. Knee kinetics, kinematics and PVGRF of 30 healthy female (age =  $13.80 \pm 1.76$  yrs, height =  $1.58 \pm .09$  m, weight =  $49.89 \pm 10.19$  kg) and 26 healthy male (age =  $13.54 \pm 1.79$  yrs, height =  $1.63 \pm .11$  m, weight =  $52.90 \pm 13.25$  kg) youth soccer players were collected. Subjects took a three-step approach and performed a stop-jump maneuver to “head” an imaginary soccer ball. Peak Motus 4.3 motion analysis system and a Bertec forceplate was used to collect the kinetic and kinematic data. The dependent variables (normalized to bodyweight or bodyweight and height) were; proximal anterior tibial shear force maximum and at initial foot contact, knee flexion (+)/extension (-) and varus (+)/valgus (-) moments at maximum proximal anterior tibial shear force and at initial foot contact, peak knee flexion angle, and peak vertical ground reaction forces. A double-leg landing style was completed, with the right leg being used for all data analyses. We performed a stepwise multiple regression analysis to determine the relationship between PVGRF with all combinations of lower extremity kinetic and kinematic variables. A univariate analysis of variance ( $p < .05$ ) was also performed to determine whether gender differences existed for PVGRF. Regression analyses revealed that peak proximal anterior tibial shear force, varus(+)/valgus(-) moment at peak proximal anterior tibial shear force, and peak knee flexion angle were significant

predictors of PVGRF (adjusted  $R^2 = .486$ ,  $p = .001$ ). There were no significant differences found between gender for PVGRF during the jump-landing task. Individuals performing the stop-jump phase of a jump-landing task landing with greater peak proximal anterior tibial shear force, increased valgus moment at peak proximal anterior tibial shear force, and lower peak knee flexion angle are vulnerable to incur greater PVGRF during landing. This information may have implications in the design of intervention strategies to reduce PVGRF and ACL injuries.

### Recurrent Patellar Instability In An Adolescent Female Athlete

Crawford SD, Sauers JL, Dersam M, Valovich McLeod TC: Department of Sports Health Care, Arizona School of Health Sciences, Mesa, AZ

A 14 year-old multi-sport female athlete presented with chronic dislocations of her left patella. The history of dislocations began at age 12 with approximately 10 total dislocations that occurred during both athletics and ADL. The first dislocation occurred from blunt trauma to the knee, while others occurred during the transition from standing to walking. The most recent incident occurred from planting and twisting during a volleyball match. The athlete then visited a physician and was referred to physical therapy. Upon initial evaluation, the athlete presented with a swollen knee, increased patello-femoral pain, notable patellar hypermobility, and palpable tenderness of the patellar borders. She demonstrated deficits in both left knee ROM and quadriceps strength. Joint line swelling demonstrated a 2 cm increase in size compared bilaterally. The short-term goals at this time were to decrease swelling to a minimal amount, increase AROM to  $140^\circ$ , and have the patient to perform a SLR without an extensor lag. Differential diagnoses included patellar fracture, meniscal injury, and ligament sprain. X-rays were taken in the A/P, lateral, and merchant views and were negative for a fracture but demonstrated signs of patella alta. The athlete continued to improve, but was still symptomatic with limited ADL function and significant patellofemoral crepitus. During a follow-up visit, it was recommended that she under-go a tibial tubercle transfer to realign the patellar to an optimal position to prevent the chronic dislocations. This option was discussed due to the history of

dislocations and slow progression with rehabilitation. The athlete opted for the surgical procedure, which consisted of a transfer of the tibial tubercle slightly distal and medially 8-10 mm. A lateral release was performed prior to the transfer to allow patellar orientation. After the tibial tubercle transfer was performed, the surgeon noticed an inflamed medial retinaculum. The medial retinaculum had pulled away so a medial reefing was performed. The surgeon also found grade 3 degenerative changes of the medial and lateral facets of the patella and the lateral femoral condyle. The patient was placed in a knee immobilizer and on crutches for two weeks post-surgery. Physical therapy was initiated after the two-week rest period. During the initial post-surgery visit, she presented with moderate level pain and swelling in her left knee and calf. The left leg ROM was measured  $0-10^\circ$  compared to the right knee of  $0-135^\circ$ . She was unable to perform a SLR or a visible quadriceps contraction. Girth measurements revealed a 1.90 cm atrophy of the VMO, and 1.27 cm swelling of the calf compared bilaterally. The athlete's initial rehabilitation program after surgery focused on restoring ROM, quad sets with electrical stimulation to the VMO, straight leg raises, and rectus femoris, hamstring and calf stretches. A home neuromuscular unit was used daily for pain and swelling. Scar immobilization was initiated when her incision was fully healed. Gait training was used to wean off crutches and then out of her immobilizer. At 6 weeks post-op she complained of intermittent pain, had a poor but visible quad set, decreased knee flexion during gait,  $90^\circ$  of flexion, and could perform an independent SLR. At 8 weeks post-op she had mild swelling, a fair quad set, normal gait on level surfaces but difficulty with stairs,  $105^\circ$  of flexion, and an independent SLR with mild extensor lag. After 12 weeks of rehabilitation she had minimal swelling, a good quad set, weak eccentric quads with step downs,  $130^\circ$  of prone flexion, and no extensor lag with SLR. She worked on the leg press and the total hip machine. The patient completed 16 weeks of physical therapy with 1-2 visits per week. At this point, her insurance benefits were exhausted and she was discharged to a home and gym program with an open patella knee sleeve for sports participation. At discharge, she still complained of patellar pain with prolonged sitting in class, but no pain with running, jumping, or ADL. ROM was WNL with no swelling present or recurrent patellar subluxation/dislocations. The athlete is currently participating in

athletic activities with no recurrent dislocations. This case is unique due to the athlete's young age, number of subluxation/dislocations, and the grade 3 degenerative changes of the patella and lateral femoral condyle.

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### **Physical And Strength Characteristics Predict Knee Flexion During A Jump Landing**

Abt JP, Ferris CM, Sell TC, Myers JB, Lephart SM: Neuromuscular Research Laboratory, Sports Medicine and Nutrition, School of Health and Rehabilitation Sciences, University of Pittsburgh, Pittsburgh, PA

Previous research has identified physical and strength characteristics that may be related to the increased rate of ACL injuries in females. Jump landing tasks have been implicated as a mechanism of ACL injury. The purpose of this study was to determine the influence of physical and strength characteristics on knee flexion during a jump landing task. Fifty-three healthy, high school female athletes (Age:  $14.2 \pm 1.4$  years, Height:  $1.64 \pm .08$  m, Mass:  $55.75 \pm 10.07$  kg) participated. Physical and strength characteristics included Body Mass Index, pelvic width-femur length ratio, Tanner developmental scale, hip abduction strength, and quadriceps and hamstrings strength. Body Mass Index was calculated as the ratio of the subject's mass to squared height. Pelvic width-femur length ratio was calculated as the ratio of the distances between the ASIS and superior portion of the greater trochanter and lateral knee joint line. Isometric hip abduction strength was measured with an isokinetic dynamometer at  $15^\circ$  of hip abduction. Isokinetic strength characteristics were measured with an isokinetic dynamometer at  $60^\circ \cdot \text{sec}^{-1}$  and  $180^\circ \cdot \text{sec}^{-1}$ . Subjects completed the Tanner developmental scale to subjectively describe their secondary sex characteristic growth. The jump landing task consisted of a double-legged vertical jump for maximal height. Limited landing instructions were provided to promote natural performance of the task. A stepwise, multiple linear regression analysis was performed to determine whether the physical and strength characteristics predicted knee flexion during the jump landing task. Decreased time to peak knee extension torque at  $60^\circ \cdot \text{sec}^{-1}$ , decreased time to peak knee flexion at  $180^\circ \cdot \text{sec}^{-1}$ , increased hip abduction strength, and advanced Tanner stage development predicted greater knee flexion (cumulative

$R^2 = .40$ ,  $p < 0.001$ ). Performance of a jump landing task may be modified based on the physical and strength characteristics of the individual. Decreasing the time to peak torque during knee extension and flexion may influence the ability to dissipate joint forces by permitting greater knee flexion during jump landings. Increased hip abduction strength may stabilize the hip during a jump landing, thus placing the knee in a less vulnerable position. Increasing knee flexion may be related to the physical development of the subject and the concomitant growth-related changes in strength and agility. Modifying the physical and strength characteristics of the subject and biomechanical performance of tasks implicated in female ACL injuries may decrease the overall risk of injury by avoiding the vulnerable knee positions.

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### **Comparison Of Muscle Activation Patterns In Boys And Girls During A Simple Landing Task**

Buckley BD, Kaminski TW, Tillman MD: University of North Florida, Jacksonville, FL

Since the passing of Title IX of the Educational Amendments of 1972 there has been a significant increase in female athletic participation. Paralleling this has been a rise in the number of knee injuries, specifically to the ACL, sustained by female athletes at all levels of competition. Researchers have suggested that these injuries may be a result of neuromuscular and biomechanical factors that females tend to display while performing "at risk" maneuvers. While the research is extensive in this area, there are few articles addressing the landing strategies of young children. Therefore, the purpose of this study was to compare quadriceps and hamstring muscle activity and knee flexion angle at ground contact during a single leg landing in two groups of boys and girls. Ten boys and 10 girls between 5 and 6 years old (Group 1) and 10 boys and 10 girls between 10 and 11 years old (Group 2) performed a simple landing task. The Noraxon Telemetry (Noraxon U.S.A., Inc., Scottsdale, AZ) telemetry surface EMG system recorded muscle activity and NorAngle electrogoniometer measured knee joint angle during the landing activity. Results of independent t-tests demonstrated no significant difference in muscle activity and knee flexion angle between boys and girls in Group 1. Interestingly, there was a significant difference in knee flexion angle between the boys and girls in Group 2

( $P < .05$ ). Girls landed with the knee in a more extended position ( $18^\circ$ ) while the boys landed with the knee in a more flexed position ( $31^\circ$ ). There was, however, no difference in muscle activity between the boys and girls in Group 2. These findings suggest that girls are developing landing strategies that may put the knee in a more vulnerable position for injury at a very young age. As a result, it may be important to implement a training program that emphasizes proper landing strategies, particularly those strategies that work to increase knee flexion angle, before the age of eleven. Although no differences in muscle activity were detected between the boys and girls in our study, it has been reported that females tend to rely more on their quadriceps muscles for knee joint stabilization. This muscle activity combined with decreased knee flexion puts the ACL at risk for injury. Future research should examine the landing strategies of children in multiple age groups and determine when the difference in landing patterns between boys and girls emerge.

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### **Gender And Age Differences In Valgus-Varus Knee Positions Of Basketball Players During Single Leg Landings**

Buchanan PA, Vardaxis VG: Bowling Green State University, Bowling Green, OH, and Des Moines University, Des Moines, IA

This study evaluated valgus-varus knee positions during single leg landings of competitive basketball players for differences related to gender and age. We hypothesized: 1) knee positions for prepubescent and peripubescent female (F) and male (M) players would be similar, 2) postpubescent female players would have more valgus knee positions than male players, and 3) valgus positions would more likely occur during weaker leg landings. Fifty players (9-10 year olds: 7 F, 6 M; 12-13 year olds: 10 F, 11 M; 16-22 year olds: 9 F, 7 M) with intact knees consented to the study. We recorded peak isokinetic strength for the ankle, knee, and hip musculature, and summed these values within legs to determine players' strength dominant legs. Players dropped from a bar (as reflected by their vertical jump displacement) and landed on their strength dominant and nondominant legs. Based on kinematic and kinetic data, knee distances from the local plane of the landing leg represented valgus-varus knee position at initial contact and minimum

position (towards valgus) during the initial 100 ms of contact. Three-way ANOVA (between gender and age; within leg) indicated knee position at initial contact differed by gender for 9-10 year old vs. 12-13 year old ( $p=.004$ ) and 12-13 year old vs. 16-22 year old ( $p=.002$ ) players, but not by age or leg. Follow-up two-way ANOVA revealed gender effects for peripubescent ( $p=.023$ ) and postpubescent players ( $p=.032$ ). No differences occurred in minimum distances for 9-10 year old vs. 12-13 year old players, but gender ( $p=.002$ ) and age ( $p=.049$ ) effects existed for 12-13 year old vs. 16-22 year old players. Gender effects were significant for the peripubescent group ( $p=.003$ ). There were no significant leg effects; however, female players demonstrated varus knee positions only at the postpubescent level with dominant leg landings. In sum, peripubescent and postpubescent female basketball players landed with more valgus knee positions than male players. The approach used here to assess knee position during acceleration-deceleration is similar to existing qualitative observational techniques that focus on relative valgus-varus knee position. It appears promising for identifying athletes who may be at greater risk for ACL injuries.

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#### **Lower Extremity Joint Kinematics Differ Between High School And College Female Athletes During Drop Landings**

Adolph JT, McCaw ST, Hopkins JT, Hanaki S: Biomechanics Lab, Illinois State University, Normal, IL

Females have a higher susceptibility to incurring non-contact anterior cruciate ligament (ACL) injury than males. The higher incidence in females has been attributed to factors such as neuromechanics, joint laxity, limb alignment, notch dimensions, and ligament size. Research to date has primarily focused on the comparison between the two genders and factors that predispose females to a higher rate of ACL ruptures. Little research has focused on the effect of experience within the female athlete. The purpose of this study was to compare the lower extremity kinematics of a group of high school female athletes to a group of university female athletes during drop landings. Eight high school (HS) athletes (age: 14 y; mass:  $55.8 \pm 5.1$  kg; height:  $162.8 \pm 5.4$  cm) and seven university (U) athletes (age:  $21 \pm 1.29$  y; mass:  $76.0 \pm 11.7$ ; height:  $178.1 \pm 6.7$  cm) participated in the

study. Each participant was in-season at the time of the study. Each participant stepped from a 0.38 m box to land while recorded with two high speed video cameras (120Hz). Kinematic measurements were made from the right leg. Ten landings were completed by each participant, with eight used for analysis. The eight trial mean value of each of six measures of joint position and velocity for the ankle, knee and hip joints were calculated from the sagittal plane kinematic data of each participant. The eight trial mean value of each subject for each variable was entered into uncorrelated t-tests to determine the statistical significance of differences between the two groups ( $P \leq .05$ ). Results indicated that the two groups made initial contact in similar upright positions, but there were significant differences evident during landing for variables describing the joint kinematics. University athletes exhibited greater hip ROM ( $17^\circ$  greater), peak angular velocity values, and time to angular velocity values compared to the HS athletes. At the knee joint, U athletes exhibited  $20^\circ$  greater ROM, nearly 100ms longer to the time of maximum knee flexion angle, greater peak angular velocity and a longer time to peak angular velocity. In addition, U athletes utilized nearly  $19^\circ$  greater ROM at the ankle joint during landing than HS female athletes. The results of greater ROMs and higher peak angular velocities suggest that high school female athletes utilize a stiffer technique when landing compared to university female athletes.



## Free Communications, Oral Presentations: H-Reflex

Friday, June 18, 2004, 2:30PM-3:30PM, Room 338; Moderator: B. Andrew Krause, PhD, ATC

### Pre-Synaptic Modulation Of Quadriceps Arthrogenic Muscle Inhibition

Palmieri RM, Weltman A, Edwards JE, Tom JA, Saliba EN, Mistry DJ, Ingersoll CD: University of Virginia, Charlottesville, VA

Knee joint pathology, whether acute, chronic, or experimentally induced, results in weakness of the quadriceps musculature acting about the knee joint complex. This phenomenon has been termed arthrogenic muscle inhibition (AMI) and is defined as an ongoing reflex inhibition of musculature surrounding a joint following distension or damage to structures of that joint. AMI hinders rehabilitation by preventing gains in strength and restoration of normal proprioceptive function resulting in persistent functional deficiencies, the possibility for re-injury, and potentially placing patients at risk for chronic degenerative joint conditions. In order to develop an effective intervention to reduce or remove AMI, thereby improving chances at successful rehabilitation of the injured joint, it is imperative to understand the neuromuscular mechanisms responsible for the quadriceps weakness. Therefore, the purpose of this investigation was to determine if quadriceps AMI is mediated by a presynaptic mechanism. Eight healthy adults (three females and five males; age:  $24 \pm 12$  yrs; height:  $167.64 \pm 7.3$  cm; mass:  $78.2 \pm 14.7$  kg) were admitted into the General Clinical Research Center on 2 separate occasions, during one admission subjects had their knees injected with 60mL of sterile saline and in the other admission they did not. Maximum H-reflex and M-wave amplitudes were recorded to establish the presence of AMI. Plasma epinephrine and norepinephrine levels were obtained to determine if a sympathetic response was elicited following the joint effusion. Presynaptic modulation of the test H-reflex amplitude was assessed using an experimental conditioning paradigm, paired reflex depression (PRD). For PRD, two stimuli of the same intensity were delivered 80 msec apart. Measurements were recorded at 5 time intervals: baseline, post needle stick, post lidocaine, 25 and 45 minutes post effusion. Measurements for the control condition were time matched to the effusion condition. 2 x 5 repeated measures ANOVAs were used to analyze each dependent variable. Hmax decreased

and PRD increased at 25 and 45 minutes post effusion during the effusion admission ( $P < 0.05$ ). No differences were noted for the maximum M-wave, plasma epinephrine and/or norepinephrine levels in either admission ( $P > 0.05$ ). No differences were detected at any time interval for any measurement during the control admission ( $P > 0.05$ ). Quadriceps AMI elicited by a knee joint effusion is at least in part, mediated by a pre-synaptic mechanism. Research should focus on discovering an intervention that is successful in removing presynaptic inhibition and thus may be successful in reversing quadriceps AMI.

### Intersession Reliability Of A Protocol To Assess Reflex Activation History In The Vastus Medialis

Ingersoll CD, Palmieri RM: University of Virginia, Charlottesville, VA

Motoneuron activation can be regulated by pre-synaptic and/or post-synaptic mechanisms. Paired reflex depression (PRD) a measurement of reflex activation history has been described as being related with other neural controls acting pre-synaptically to gate motoneuron output. A protocol to assess PRD has been developed for the soleus musculature and the reliability has been established. The current investigation was conducted to determine if the protocol developed to assess PRD in the soleus was able to reliably evaluate PRD in the vastus medialis. Eight healthy adults (three females and five males; age:  $24 \pm 12$  yrs; height:  $167.64 \pm 7.3$  cm; mass:  $78.2 \pm 14.7$  kg) volunteered to participate in this study. Subjects reported to the laboratory on two separate occasions. Testing sessions were separated by two to seven days (Average = 5 days). PRD was assessed by delivering two stimuli of the same intensity 80 msec apart. The dependent variable evaluated was the percentage of the unconditioned reflex amplitude (Conditioned H-reflex / Unconditioned H-reflex). Eight trials were obtained for all subjects on each day to assess the intersession reliability of the protocol. The random effects model to determine intraclass correlation coefficients (ICC 2,1) was used to estimate intersession reliability. The intraclass correlation coefficient for the protocol was found to be 0.9647. The results of this investigation indicate that this technique can reliably

estimate vastus medialis PRD, a pre-synaptic mechanism acting to gate motoneuron output.

### Consistency Of Hoffmann Reflex Measurement In Male Subjects Over A 28-Day Period

Hayes BT, Harter RA, Hoffman MA: Oregon State University, Corvallis, OR

Published reports of the consistency of the Hoffmann (H) reflex obtained in the prone position vary widely, with previous reliability estimates ranging from  $R = .29$  to  $.99$ . To date, no known studies using the H-reflex and M-wave have reported reliability over long periods of time with multiple measurements. Therefore, the purpose of this study was to assess the reliability of the H max / M max ratios of male subjects obtained at 4-day intervals over a 28 day period. Fifteen male college students (age =  $22.2 \pm 3.9$  yr, ht =  $181.2 \pm 11.1$  cm, mass =  $74.9 \pm 9.2$  kg) were recruited via flyer. Subjects reported to the laboratory every fourth day for a 28-day period and had no history of lower leg pathology or neurological disorder. Subjects were instructed to lie prone on a modified massage table that positioned the ankle at  $90^\circ$ . EMG recording electrodes were placed on a shaven area on the left soleus muscle belly. The stimulation electrode used for elicitation of the H-reflex and M-wave was placed over the tibial nerve in the popliteal fossa. For accurate placement on subsequent days, the locations of the stimulating and recording electrodes were outlined with permanent marker. The dependent variable, H max / M max ratio, is the division between maximum peak-to-peak amplitude of the H-reflex and the maximum peak-to-peak amplitude of the M wave. The H max / M max ratio was chosen as the dependent measure because it is a measure of the connectivity between the sensory and motor sides of the reflex circuit. An intraclass correlation (ICC 2,1) was used to quantify the reliability of the H max / M max ratio measurements. The average H max / M max ratio for all subjects was  $.58$  ( $SD \pm .194$ ) with a range from  $.17$  to  $.93$ . Our results indicate excellent consistency of H max / M max ratio measurement across subjects with an ICC of  $R = .985$  over the seven testing days. The excitability of the reflex loop as measured

by the H max /M max ratio remained consistent and reliable in males throughout the 28-day period thus justifying its inclusion in future research studies.

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### **The Relationship Between Muscle Stiffness And Spinal Stretch Reflex Sensitivity In The Triceps Surae**

Blackburn JT, Guskiewicz KM, Padua DA, Mynark RG, Giuliani CA, Weinhold PS: University of North Carolina at Chapel Hill, Chapel Hill, NC

Muscle stiffness may contribute to joint stability from both mechanical and neuromuscular perspectives. The spinal stretch reflex (SSR) is an integral component of neuromuscular control, thus contributing to joint stability. It was hypothesized that *higher* levels of triceps surae (TS) stiffness would correspond with *shorter* SSR latency and *greater* SSR amplitude in the soleus via enhancement of the mechanical coupling of the muscle spindle and the stretch stimulus. TS stiffness, the soleus H-reflex, and the soleus SSR were assessed in 20 males (height=1.81±0.06 m, mass=81.83±12.21 kg, age=22±3 years) and 20 females (height=1.67±0.07 m, mass=63.55±9.84 kg, age=22±3 years). For each of these assessments, subjects were seated with the soleus active to approximately 15 %MVC. Stiffness was estimated from the damping effect imposed by the TS on oscillatory motion about the ankle in the sagittal plane. The soleus H-reflex was elicited by electrically stimulating the tibial nerve. The soleus SSR was evoked via transient rapid ankle dorsiflexion perturbation, stretching the TS. Independent samples t-tests were used to evaluate group differences in TS stiffness, soleus H-reflex latency and amplitude, and soleus SSR latency and amplitude. Relationships between TS stiffness and SSR latency and amplitude, respectively, were assessed via bivariate correlational analyses. Statistical significance was established *a priori* at  $\alpha=0.05$ . TS stiffness in males was approximately double that of females ( $p<0.05$ ). Therefore, remaining variables were compared across high (males) and low (females) TS stiffness groups. Soleus H-reflex latency and amplitude were not significantly different between stiffness groups ( $p>0.05$ ). Similar H-reflex characteristics across stiffness groups suggested that any differences observed in SSR characteristics would have resulted from peripheral influences (i.e. the muscle spindle), as central components did not

differ. Because experimental variables known to affect SSR characteristics were standardized across groups, the two groups differed only on TS stiffness. However, soleus SSR latency and amplitude did not differ across stiffness groups ( $p>0.05$ ). Similarly, the relationships between TS stiffness and soleus SSR latency and amplitude, respectively, were not significant ( $p>0.05$ ). Previous research indicates SSR sensitivity is related to the muscle length-tension relationship, and likely to series elastic stiffness, but is also dependent on fusimotor drive. It was concluded that the similarity of SSR characteristics in the presence of varying levels of series elastic stiffness was due to the combined effects of series elastic TS stiffness and fusimotor activity to achieve set-point output values for SSR latency and amplitude for standardized kinematic, postural, and neural conditions. Supported by a grant from the NATA Research & Education Foundation sponsored by Proctor & Gamble.

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## Free Communications, Clinical Case Reports: Underlying Medical Conditions

Saturday, June 19, 2004, 8:00AM-11:00AM, Room 338; Moderator: Cliff Fawcett, FNP, ATC;

Discussant: Garath Maenpaa, MD

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### Thigh Mass In Middle School Football Player

Blair DF, Peyton CC, Freed SD:  
Wenatchee High School, Wenatchee, WA;  
Washington State University, Pullman,  
WA; and Wenatchee Valley Medical  
Center, Wenatchee, WA

An 11 year-old white male reported for a team physical prior to his football season with a large mass in his thigh. At the age of four, he indicated he had received a contusion to the distal femoral region and a small mass was noted at that time. Follow-up radiographs showed an abnormality that was thought to be a post-traumatic osteal myositis. Over the past seven years, the mass had remained rather constant in size. However, an increase in the size of the mass was noted six to eight weeks prior to its discovery at physical night. The athlete also noted that the growth of the mass during this period had been exponential. During a basic musculoskeletal screening by a certified athletic trainer, a sizeable mass was found in the anteromedial distal thigh. The deformity was visible even through his pants. He exhibited slight tenderness over involved area. The athlete demonstrated no difficulty with running or sports activities. Range of motion tests established relatively normal levels of flexibility and mobility. He had no other bone pain and no systemic symptoms. Differential diagnosis: Myositis ossificans; Osteosarcoma; Chondrosarcoma; Osteochondroma; Chondroblastoma; Endochondroma; Giant cell tumor; Myeloma. X-rays revealed an ossified, irregularly shaped mass. The mass appeared to be coliform-shaped and about six by eight centimeters in size. The results of the CBC returned with normal blood chemistry levels. A bone scan indicated an increased uptake in left femur and no other bone abnormalities. The CT scan of the brain did not reveal any acute hemorrhaging or abnormal areas of enhancement. The initial evaluation occurred on August 11, 2003 during physicals. The following day, the physician who had evaluated him the night before ordered a battery of tests including enhanced CT, bone scan, and laboratory work. He was then immediately referred to a children's orthopedic hospital for additional tests and a surgical consultation. Upon reviewing the imaging, it was determined that the mass was entangled with the bone. A

calcium deposit underneath the cap of the tumor was also concerning for the surgeons. Surgical excision of the mass was performed on September 4, 2003. Upon excision, it was determined that the mass was an osteochondroma, a benign bone tumor generally occurring during periods of skeletal growth between the ages of 10 and 25 years, most typically during adolescence. Post-surgically, the athlete was released from the hospital the following day and carried out a regular home rehabilitation program. He was cleared to play basketball on November 10, 2003. He has greatly exceeded the physician's expectations with his rapid recovery. The extended course of this bony mass was very unusual. This athlete carried a mass for seven years before this benign tumor started to grow. The speed of growth of this tumor was also remarkable. It had significantly increased in size even in the short three-week period from initial diagnosis to surgical removal. It is important to carefully recognize and identify any masses or lumps in soft tissue (which might be confused with a myositis ossificans) to rule out the possibility of tumors early in the evaluative process.

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### Dyspnea In A Collegiate Athlete

Walters SL, Melendez A, McDonald JD,  
Horodyski MB: University of Florida,  
Gainesville, FL

A 22-year-old African American male collegiate football player with no previous or family history of asthma or other lung disease began experiencing upper respiratory infection like symptoms in mid-November. The athlete was initially diagnosed with bilateral otitis media, pharyngitis, and Eustachian tube dysfunction (ETD). One month later, the athlete had experienced no relief with treatment (antibiotics and decongestants) and the symptoms progressed to his chest. He complained of worsening coughing and chest congestion. At this point he was diagnosed with sinusitis, ETD, and exercise induced bronchospasm. He was treated with an oral antibiotic and albuterol MDI. During this time the athlete continued to participate in his normal physical activities with some relief with the use of the MDI. The symptoms progressed to the point that the athlete was complaining of constant lethargy and

dyspnea, with wheezing during physical activity. In late February while at home for a weekend, the symptoms worsened and he was taken to the emergency room. At this point he complained of polyuria, polydipsia, and nocturia. It was suggested by the ER staff, based on these symptoms, with no testing, that he may be diabetic and should consult a specialist upon returning to school. The athlete was also experiencing weight loss and occasional light-headedness at this time but did not mention this until being questioned regarding diabetes. He did have a prior family history of diabetes mellitus. Differential diagnoses: 1. asthma, 2. exercise induced bronchospasm, 3. ETD, sinusitis, 4. atypical bronchitis, 5. allergic rhinitis, 6. tuberculosis (TB), 7. sarcoidosis, 8. Type I diabetes mellitus. At the ER, a chest x-ray read as normal. Fasting plasma/blood glucose and urinalysis revealed hyperglycemia. Other initial labs (i.e. CBC, chemistries) were normal. Chest computed tomography (CT) with contrast bronchoscopy, blood work, and pulmonary function tests were indicative of pulmonary sarcoidosis. A TB skin test was negative. The athlete was diagnosed with Type 1 diabetes, prescribed Lantus and was provided with nutritional counseling. Six weeks later, no marked improvement in respiratory function was demonstrated. The athlete was then referred to a pulmonologist for evaluation and was diagnosed with sarcoidosis. He was prescribed a prednisone treatment protocol. The endocrinologist believed the diabetes mellitus would resolve once the sarcoidosis was controlled. The pulmonologist predicted that the athlete would completely recover from the sarcoidosis in 2-3 months. Athlete was also referred to a cardiologist to rule out any cardiology etiology and none was found to be present. While on the Lantus and prednisone treatment, the athlete's condition has improved dramatically. The athlete was limited initially in physical activity but by May was participating without limitations. His course of treatment of Lantus and prednisone was continued with gradual decrease in the both doses until cessation in early November. Sarcoidosis is a multisystem condition of unknown origin resulting in noncaseating epithelioid cell granulomas. It is not typically seen in otherwise healthy young male athletes. African Americans do appear to be more



susceptible to the condition. Pulmonary sarcoidosis generally has atypical clinical symptoms making its initial diagnosis difficult in this setting. As in this case, it is typically missed diagnosed as asthma or bronchitis in otherwise healthy populations.

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### **Amplified Musculoskeletal Pain In A 10 Year Old Club Soccer Player**

Middlemas DA, Schechter WF, Benstock AD: Montclair State University, Upper Montclair, NJ

The athlete was a ten year old female soccer player on a youth club soccer team. The athlete initially complained of soreness in the first metatarsophalangeal joint of the left foot with no identifiable incidence of injury. The pain significantly intensified and spread throughout the foot and lower leg. The pain was accompanied by allodynia, hyperesthesia, cold skin, intermittent discoloration of the third and fourth toes and inability to bear weight. The athlete had no previous medical history and had played previously without incident. The primary complaint was pain in the left foot and lower leg and coldness in the extremity. The athlete presented with significant pain in the first m-p joint of the foot and throughout the foot and lower leg. She also complained of hyperesthesia, allodynia and coldness in the foot and lower leg. This child-athlete's pain was inconsistent with any incidence of injury or other stimulus. The pain became progressively worse during the three days following the initial complaint of foot soreness with progressive loss of ability to weight bear. Differential diagnoses for this injury included infection, post-streptococcus infection, insect bite, Lyme disease, stress fracture of sesamoid, Raynaud's phenomenon, septic or inflammatory arthritis, Rheumatoid arthritis, vasomotor abnormality, peripheral neuropathy, psychogenic, hysterical paralysis, Sudek atrophy, sprain or strain of the m-p joint. Plane film x-ray was negative for fracture to the foot. Doppler ultrasound and vascular studies of the foot and lower leg were normal. Blood tests and EKG long strip for QT interval were normal. Technetium MDP Bone Scan of both feet was normal. The patient was diagnosed with Complex Regional Pain Syndrome (CRPS) Type I. The course of treatment for this patient involved two weeks of aggressive, daily physical therapy. Treatment included electrical stimulation, contrast bath therapy, desensitization activities, passive and active range of motion exercises and rapid return

to weight bearing. Additionally the patient was prescribed Neurontin and Lidoderm patch. After this two week period the athlete was given a home program of contrast baths, desensitization, weight bearing and walking with progressive return to running and kicking. She continued taking medication for another three weeks. The athlete returned to practice and competition 6 weeks after the onset of symptoms. At her physical examination eight weeks post-onset she presented symptom free and had returned to activity. What makes this patient unique is that CRPS Type I is uncommon in children. In addition, CRPS usually follows a defined incidence of injury, like an immobilized fracture. This patient did not identify any predisposing injury or condition prior to the onset of soreness and intense pain. As the diagnosis of CRPS is one of exclusion based on clinical presentation and lack of another pathology to explain the pain, the practitioner must be acutely aware of the possibility of the condition when young athletes present with unexplained pain.

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### **Diagnosis Of Marfans Syndrome In A 20-Year Old Volleyball Player**

Apers ME, Guyer MS: Springfield College, Springfield, MA

A 20-year old male volleyball player came into the athletic training room requesting strengthening exercise for his right shoulder as a preventative measure prior to the start of his season. The athlete denied any acute mechanism of injury or pain in or around his right shoulder and stated that he was in good health. During the examination of the patients right shoulder, absents of the infraspinatus muscle was noted. Palpation of the infraspinatus fossa revealed no proximal muscular attachment of the infraspinatus muscle. History of right shoulder injuries included a non-diagnosed "tear" during his senior year in high school and minor rotator cuff tendonitis during his college career. Further investigation revealed a funnel chest and rounded shoulders. The athlete stated that his pediatrician had previously diagnosed him with a heart murmur. No previous cardiovascular testing had been ordered. The athlete stands at 6'5" and weights 162 # and presented with somatotype characteristics consistent with ectomorph. The athlete did not present with disproportionate arm or leg length, however the athletes arms, fingers and legs are very long. Arm span was slightly longer than standing height. The athlete presents with no family history of

cardiovascular disease or sudden unexplained death. The athlete did have a life threatening brain tumor at age four which was surgically removed. During the evaluation the athletic trainers performing the evaluation were concerned with a possible connective tissue disorder or Marfans syndrome. Consultation with the team physician and athlete were scheduled. The physician was presented with the case and agreed that cardiovascular screening should be done immediately. Heart sounds were evaluated and confirmation of a heart murmur was revealed. An echocardiogram was ordered to assist with the diagnosis of the possibility of Marfans Syndrome. An appointment for an echocardiography was scheduled. A complete 2-D, color Doppler and spectral Doppler analysis were performed. Indications for the echocardiography were cardiac murmur. Significant findings included; Normal left arterial size and left ventricular cavity size top-normal with normal left ventricular wall. The left ventricular function was low-normal measuring 50-55% without evidence of regional wall motion abnormality. The mitral valve appeared to be thickened at its tips and redundant with an elongated anterior leaflet of the mitral valve with moderate anterior leaflet prolapse and mild mitral regurgitation present. There was evidence of blunted systolic component of the pulmonary venous flow that is suggestive of elevated left atrial pressures. The totality of the echocardiograph findings suggested the possibility of Marfan syndrome. Cardiovascular and eye examinations were scheduled. An appointment with an optomologist was scheduled to evaluate the health of the athlete's eyes in particular the optic lens. The optic lens was within normal limits indicating no thickening or displacement. The athlete presents with 20/20 vision. Examination revealed no abnormal findings. The athlete does present with a family history of glaucoma although no indications of symptoms existed in the athlete. Referral to a Cardiologist was scheduled and a repeat echocardiogram was performed. The Cardiologist ordered a CT scan of the chest and abdomen to evaluate for possible aneurysm. Findings to the CT scan revealed a 2x2x2cm mass posterior to the athletes' aorta and anterior to the vertebral bodies. Further testing is being ordered to help identify the mass. Genetic testing was not performed for numerous reasons. Diagnostic testing confirmed the suspicion of Marfans syndrome. The athlete appeared healthy, the only exception being the unusual nature of the muscular tearing

in his shoulder. The athletic trainers performing the evaluation would not have screened the athlete for Marfan syndrome based solely on his physical characteristics and only became suspicious due to the nature of his shoulder musculature.

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### **Celiac Disease In A Female Collegiate Volleyball Player**

Eberman LE, Cleary MA, Zuri RE,  
Salvador G: Florida International  
University, Miami, FL

We report a case of a National Collegiate Athletics Association Division I female volleyball player (age = 19 yr, height = 183 cm, body mass = 81 kg) who complained of diarrhea and fatigue following preseason training of her sophomore season. The athlete lost a considerable amount of body mass (-8.1 kg) during the first 20 days of training and she was falling asleep at meals and prior to and during practices for which she was not participating. Our case is unique in that, based upon drastic body mass losses and observations of the patient's behavior, initially an eating disorder was suspected. For her own safety, the athlete was removed from volleyball practice and she was confronted about her behavior by the staff Certified Athletic Trainer and the eating disorder liaison. At this time, the differential diagnoses included anorexia athletica, bulimia, anorexia nervosa, or gastrointestinal dysfunction. After an intensive interview process, the sports medicine team determined that the athlete was not presenting clinically relevant psychological symptoms of an eating disorder and the athlete was referred to the University Health Center for a physical evaluation. Initial blood tests revealed critically high platelet counts suggesting a possible blood disease or cancer which initiated further testing and referral to a gastroenterologist. The diarrhea, weight loss, and laboratory findings were indicative of active celiac disease which required a duodenal biopsy and serologic testing to confirm the diagnosis. The duodenal biopsy revealed diffuse loss of villi, crypt hyperplasia, increased inflammatory cells in the lamina propria, and intraepithelial lymphocytes. Serologic testing revealed elevated anti-gliadin and endomysial antibodies. In addition, malabsorption had led to noticeable Vitamin K and B12 deficiencies, with all findings confirming the active celiac disease diagnosis. Celiac disease, also known as gluten-sensitive enteropathy and celiac sprue, is a gastrointestinal condition affecting the small

intestine. Some investigators believe celiac disease is triggered by a life altering event or extreme stress. Often, celiac disease is diagnosed in infancy, but delayed (adult onset) is increasingly being diagnosed. One in every 200 to 400 individuals suffers from celiac disease and a majority of these patients will go undiagnosed for years. In this case, once the athlete was diagnosed, she was treated with a gluten-free diet which excludes wheat, barley, and rye. Dietary substitutions such as rice, corn, maize, flax, quinoa, tapioca, potato, amaranth, nuts, and beans are required to maintain adequate carbohydrate intake. Elite athletes present a unique challenge when implementing a gluten-free diet because of the need for a high energy fuel usually associated with the intake of wheat products such as breads, cereals, and pastas. Dietary adjustments including increasing the caloric content and frequency of meals are necessary to meet the energy needs of highly physically active individuals. This athlete was unable to return to volleyball practice immediately, but as she learned to alter her diet to meet the caloric demands of her daily activities and her athletic participation, she was able to return to play. She completed her sophomore season and to date, her athletic performance has improved and has even exceeded that of her pre-illness level. For the Certified Athletic Trainer, the outward signs of celiac disease, especially in an elite female athlete, can imitate those of an eating disorder. The signs and symptoms of celiac disease are often and easily confused, and an accurate differential diagnosis requires appropriate diagnostic tests to rule out diseases with similar signs and symptoms such as anemia, Crohn's disease, and other food allergies. Undiagnosed and untreated celiac disease is life-threatening and patients who fail to follow the gluten-free diet increase risk of further disease.

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### **Head Injury In A Collegiate Volleyball Player**

Hunt TN, Amato HK: James Madison  
University, Harrisonburg, VA

During an intercollegiate volleyball competition, an 18-year-old female (height, 172.72cm; mass, 68 kg), with no history of head or face injury, collided with another player. The initial point of contact was made to the athlete's left orbital/zygomatic region. She immediately fell to the ground holding her face, reporting pain in the zygomatic region followed by severe nausea and headache. She was reluctant to open her eyes

due to pain but was able to recall the entire incident. The athlete did not lose consciousness although she had a noticeable neurological decline within minutes of the collision. The athlete had an immediate onset of edema and ecchymosis over the left zygomatic region. Decreased sensory and motor functions were noted with Cranial Nerves 5 and 6. Testing was performed using a scale from 0, no function or motion, to 5, which demonstrated full strength and motion. Initially, she demonstrated difficulty chewing (3/5) and abducting her eye (3/5) on the left side. Further, she demonstrated sensory deficits over the left upper eyelid, upper part of the nasal cavity, side of nose and forehead. Moreover, she exhibited a decrease in fine motor ability of nerve roots C5-T1 bilaterally, which was elicited with manual muscle testing of the deltoid, elbow flexion and extension, wrist flexion and extension, finger extension and grip strength. Lower extremity strength and sensation were tested and were normal. Pupils were equal and reactive to light; however, tracking was accompanied with pain. Due to the disorientation and equilibrium disturbances, the athlete was taken to the emergency room. During transportation to the emergency room, she reported pain of the right neck musculature, left shoulder and an overall feeling of weakness. A CAT scan and X-ray films of the skull, ordered by the emergency room physician, were normal. Furthermore, a follow up CAT scan was performed and was normal. When the repeat CAT scan returned normal the physician ordered an MRI. The MRI revealed elongation of the cerebellar tonsils, consistent with a diagnosis of Chiari Malformation. The presence of Chiari Malformation is often not appreciated and the patient is treated for concussion, migraine headaches, tension headaches, or post concussion syndrome. The neurologist managed the condition with medications alone, with hopes that the headaches and neurologically deficits would completely resolve. The athlete was originally treated with meclizine an antihistamine used to treat and prevent nausea, vomiting, and dizziness caused by motion sickness, and 25 mg of amitriptyline a tricyclic antidepressant used to treat chronic pain and other conditions to control symptoms. The athlete remained on medication for three weeks with no improvement. The athlete was then switched to 60 mg of amitriptyline and acetaminophen to control pain. The neurosurgeon and neuropsychologist referred the athlete to cognitive rehabilitation with a psychiatrist on campus. The cognitive rehabilitation, involved retraining or improving cognitive brain functions, and counseling to handle the stresses of chronic pain. The psychiatrist taught the athlete how to perform rhythmic

breathing, visualization along with imagery techniques to cope with stress, pain, headaches, nausea, and chronic fatigue. This therapy began to work and the athlete noticed a decrease in symptoms. The symptoms began to resolve 24 weeks post injury and continued to improve daily with prechlorperazine for nausea, vomiting and dizziness. The athlete was cleared to return to competitive volleyball, by the neurosurgeon and neurologist 39 weeks post injury. The physicians felt that in this case she could return to competition with little to no risk of further damage to brain structures. She has since made a successful return to Division 1 Volleyball. The case being presented was treated for more than 2 months without normal resolution because the symptoms of CM mimicked post concussion syndrome. The concussion exacerbated typical symptoms in this patient and CM would have gone undetected without a Magnetic Resonance Imaging (MRI). CM can be difficult to diagnose if athletic trainers and physicians do not include the potential for brain anomalies in their differential diagnosis of prolonged neurological symptoms. Any athlete with persistent neurological symptoms or an abnormal neurological examination must undergo further neuroimaging, including MRI and CT scan. Although persistent neurological symptoms are common following mild traumatic brain injury, causes other than post concussion syndrome must be considered.

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### **Bilateral Lower Extremity Paresthesia In A Collegiate Basketball Player**

Ramsdell KM, Harkins TW: Erskine College, Due West, SC

A nineteen year-old female collegiate basketball player collapsed during a one-mile fitness test. The athlete had been diagnosed with acute lymphocytic leukemia (ALL) approximately 18 months prior to the episode. She had been cleared for all sport participation, as she had completed one full year of soccer and basketball. The athlete was receiving chemotherapy treatments of Methotrexate and Vincristine at the time of the first episode. She had no previous history of central nervous system dysfunction, lower extremity paresthesia, lower extremity muscular weakness, or back pathology. Two to three minutes into the fitness test the athlete began experiencing bilateral paresthesia of her lower extremities. As she continued to run, the paresthesia intensified and she collapsed, stating that she could not feel her legs. When the athlete was removed from the course, she

was experiencing severe headache and was unable to support her own body weight. Upon return to the athletic training center, sensory deficits were noted bilaterally from L1-S1, but a motor examination was not completed due to the discomfort of the athlete. The athlete remained in the athletic training center for approximately 25 minutes, until her lower extremity sensation and strength returned to normal. She stated that after lying down for about 15 minutes, the sensation of her legs slowly returned, but the episode left her exhausted. Following a phone conversation with the team physician, it was recommended that she continue participation until another episode. The athlete was able to complete basketball drills, weight lifting, and activities of daily living within normal limits. The following week, during the same one-mile fitness test, the athlete experienced a repeat episode. She was referred to the team physician who subsequently referred her to her current oncologist for evaluation/consultation. Evaluation by the oncologist consisted of nerve conduction testing, reflex testing, and blood work. The athlete was diagnosed with peripheral neuropathy resulting from an adverse effect of the Methotrexate and/or Vincristine, which were discontinued at this time. She was cleared to continue sport participation and was informed that these episodes would continue as a result of the damage to her peripheral nerves. She participated in approximately one-half of the basketball season before returning home, due to gastrointestinal problems related to her disease. Currently, she continues to experience lower extremity paresthesia in her activities of daily living, after being off of the medications for approximately 15 months. She was informed by her physicians that her peripheral nerves had recovered as much as they were going to, and the effects she continues to experience would be permanent. This is a unique case due to the unfamiliarity of the disease and the specific chemotherapy medications. Neither Methotrexate nor Vincristine are known to cause disruption of the peripheral nerves to this extent. Both of these medications list fatigue and general weakness as possible side effects, but state that this will be temporary and will gradually improve. Vincristine lists numbness and tingling as an additional possible side effect, but states that this will occur only temporarily in the hands and feet and will improve following termination of the treatment.

### **Neck Pain In A Professional Baseball Pitcher**

Robinson KK, Potenziano B, McClean RF, Valovich McLeod TC: Department of Sports Health Care, Arizona School of Health Sciences, Mesa, AZ; San Francisco Giants Minor League Facilities, Scottsdale, AZ; and Surgical Staff, Department of Orthopaedic Surgery, Cleveland Clinic Spine Institute, and Department of Orthopaedic Surgery, Cleveland, OH

A 21-year-old right-handed minor league pitcher began presenting to his athletic training staff with pain of insidious onset in the upper cervical/ thoracic region. Pain was increased with lifting, driving, back exercises, and pitching. Findings from the initial evaluation suggested an upper trapezius strain and the athlete was treated conservatively with removal from pitching activities and placed on a strengthening program for the shoulder and back muscle groups. One month following the initial presentation, an orthopedic screening revealed a manual muscle testing of 5/5 in all shoulder and upper thoracic muscle groups. Dermatome sensation was normal to light touch and pin prick. The athlete had negative Waddells test and a 2+ deep tendon reflex. This led to an orthopaedic diagnosis of an upper trapezius strain, with recommendation for conservative treatment consisting of therapeutic modalities and exercise. Differential diagnoses included cervical strain, cervical sprain, and disc herniation. Following almost four months of conservative treatment with no improvement in the athlete's signs or symptoms, diagnostic MRI with gadolinium were taken over the cervicothoracic region, revealing increase signal in the vertebral bodies of T1- T2 on the left side. Additionally, increase signal in the adjacent parenchyma, transverse process and rib head of T2. Lobular lesions were also found in the foramen of T1-2 on the left hand side. Twelve days following the MRI evaluation, a CT T-Spine using a 17-gauge bone biopsy needle was performed on the athlete. Axial images through the cervical spine were obtained from the C5 vertebral body through the T4 vertebral body. The images demonstrate a predominantly lytic, expansile mass centered in the left superior facet of the T2 vertebrae with extension into the left posterior aspect of the T2 foramen. Fluid aerobic cultures of the left T2 vertebrae revealed gram stain negative and no organisms seen or white blood cells. The



patient underwent open biopsy and excision of the thoracic lesion through a posterior minimally invasive approach approximately 5 months following initial presentation to the athletic training staff. Minimally invasive techniques have significantly improved recovery among spine patients, but have had limited application in tumor care. The stereotactic guidance (SG) system was registered to the T1 and T2 vertebrae, selecting the two spinous processes and the facet margin as points of reference. A left-sided hemilaminotomy was performed and the SG system used to localize the tumor with minimal injury to overlying muscles. The mass was separated from the nerve root and sent for histological examination. Frozen section confirmed the diagnosis of osteoblastoma. The remaining tumor was removed and the resection margin was verified with the stereotactic wand and confirmed histopathologically. The patient went home on the first postoperative day. Six weeks postoperatively He began a graded rehabilitation program, and at six months was throwing full-speed and ready to return to competition. A follow-up MRI at nine months post-operative revealed a focal recurrence of the neoplasm at the adjacent vertebra. Because of the lesion's proximity to the spinal cord, radiation or cryotherapy therapy was not possible, and a repeat excision was necessary. The microsurgical approach was repeated on January 17, of 2003 and SG was used to carry out a more extensive bony excision at the T2 level, without extending the soft tissue dissection. The patient's recovery was again rapid, and he returned to progressive rehabilitation without further difficulties. At six months following the second surgery, he was released to return to competition. Continued follow-up has revealed no evidence of recurrence and the athlete is back to full participation. While bony spinal tumors are uncommon, they do occur in young patients and can present in competitive athletes. Axial back pain and muscle spasm can be difficult to distinguish from muscular strain or disc injury, but the diagnosis is reliably established by CT or MRI. Once the benign nature of the spinal tumor has been confirmed, one of the primary goals in treating an athlete is to limit the damage caused by the surgical exposure and tumor removal. Image guidance, in combination with evolving minimally invasive surgical techniques, accurately localizes and guides excision of benign vertebral lesions while minimizing soft tissue trauma and collateral damage, allowing patients a rapid and complete return to pre-operative function traditionally not possible.

## Free Communications, Clinical Case Reports: Upper Extremity

Saturday, June 19, 2004, 12:40PM-2:50PM, Room 338; Moderator: Todd Botto, PhD, ATC; Discussant: Janet Tsang, MS, ATC

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### **Radial Head Fracture/Displacement In A High School Football Player**

Jackson GL, Charoglu C, Mair S:  
University of Kentucky, Lexington, KY

The subject is a fifteen-year-old male football player that received a direct blow to the lateral anterior portion of his forearm during a football game. The subject is 6' tall, and weighs 185 pounds. The athlete was evaluated on the sideline and was found to have decreased strength in the affected limb and limited ROM. The lack in ROM was thought to be the result of pain. He had immediate swelling and was tender over the lateral aspect of his right elbow. He also complained of numbness of the 4<sup>th</sup> and 5<sup>th</sup> digit of the right hand. Due to pain and swelling, he did not return to the game, and was brought in for further evaluation by an orthopedic surgeon the next morning. After the initial contact, there was immediate pain and swelling laterally. ROM was limited due to pain, and strength was not equal bilaterally. He had restricted ROM of the right elbow with extension to 20 degrees and flexion approximately 100-110 degrees. The subject had limited and painful ROM with supination and pronation and a stable ligamentous exam. Differential diagnosis: Right elbow contusion; Loose body; Fracture. Radiographs were obtained and demonstrated that he had an angulated radial neck fracture. Approximately 35 degrees of angulation was noted at the fracture site. The radial capitellar joint space was widened almost one centimeter on the lateral side. The procedure performed in this case was an open reduction and internal fixation of right radial neck fracture. An incision was made from the lateral epicondyle extending distally on the anterior border of the conus muscle. Sharp dissection down to the fascia was performed. A fresh blade was then used to incise the anterior edge of the conus muscle. Deeper dissection with dissecting scissors was done with the forearm pronated. The interval between the conus muscle and the ECU muscle was exploited. The underlying joint capsule and ligamentous structures on the lateral side were then identified. An anterior incision was then made in the lateral, collateral ligament. The lateral ulnar collateral ligament was preserved. Sharp and blunt dissection distally in the region of the supinator muscle was used to make room for a plate. The

radial neck fracture was identified. A joker was then placed into the fracture site and the fracture was levered into place. Osteo set pellets were then placed in the defect to help maintain height. A 2.4mm T plate from the modular hand syntheses set was then contoured and cut to size. Two screws were placed. The first screw was placed as close to the fracture as possible. This was used as a buttress and prevented collapse of the radial head. The elbow and forearm were taken through a full range of motion, and they were found to be stable. After surgery, the subject was placed in a locked brace and instructed to begin physical therapy for active/active-assisted ROM of the right elbow and forearm. After 5 days, the doctor saw the subject, and more radiographs were obtained. All hardware appeared in tact and patient was instructed to continue doing exercises and advance in his protocol. After one month of therapy, the patient began to lose ROM and develop an increase in pain. More radiographs were obtained, but appeared to be normal. An MRI was ordered which revealed a trochlea osteochondral lesion of the right elbow. An abrasion arthroplasty of the osteochondral defect was performed. Under anesthesia, full ROM was achieved, and the original fracture site appeared normal. The patient was again referred to physical therapy for active/active-assisted ROM. Six months after the original injury, the patient was seen again. He stated a slight increase in pain and had not achieved full ROM. At that time, radiographs were once again obtained and thought to show a complete union of the fracture. It was believed that ROM could possibly be hindered by the hardware from the original surgery. Surgery was scheduled for the removal of hardware and three wks post operative, subject had regained full ROM. Radial head fractures are not an uncommon injury. They occur everyday inside and outside of sports. But, Radial head fractures with displacement rarely occur. This particular case was unique, because not only did the subject have a fracture and displacement of the radial head, the hardware needed to realign the bone was the cause of many rehab problems. The buttress and screws were needed to fix the fracture, but once union was achieved, it was removed to allow the subject to return to full motion and activity.

### **Shoulder Pain And Crepitus Following Injury In A Collegiate Football Player**

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The athlete was a twenty-one year old right hand dominant male defensive end (73.5 inches, 294 pounds) for a NCAA Division II University football team. During the fourth game of the season, he sustained a contact injury to his right shoulder as he fell on his outstretched arm after attempting to make a tackle. He felt a pop and thought his shoulder had dislocated. He had no previous injury to the right shoulder and his other past medical history was unremarkable. He was not able to finish the game and was examined by the team physician after the game. He was thought to have suffered a shoulder subluxation and was started on rotator cuff strengthening exercises. He missed two games and was then able to finish the remainder of the season with minimal pain. After the season, the shoulder pain completely subsided with rest. He was asymptomatic until spring practice when he had a repeat injury of his right shoulder when he fell on it during a drill. He was referred to the clinic when he felt he could no longer continue to participate due to pain in the posterior aspect of his right shoulder. On examination, he had full abduction and forward flexion was measured to 170 degrees. External and internal rotation was within normal limits. He had positive Neer's and Hawkins - Kennedy impingement tests. There was crepitus about his acromion and scapula posteriorly. He had a negative apprehension test and no appreciable anterior or posterior instability. Radiographs were also obtained. The differential diagnosis for this athlete included: Glenohumeral dislocation/subluxation, Impingement Syndrome, Rotator cuff pathology, AC sprain/separation, Labral tear, Acromion fracture. The radiographs demonstrated a nonunion fracture at the base of his acromion. After discussing both operative and nonoperative treatments with this athlete, the decision was made to perform an open reduction and internal fixation of his acromion fracture with instrumentation and bone grafting. The surgical treatment consisted of open reduction and internal fixation of the acromion through a posterior

approach. A 3.5 millimeter plate with locking screws was used for fixation after reduction and grafting with allograft. His acromioclavicular joint was inspected at the time of surgery and judged to be intact. He was placed in a sling post operatively and started on Codman exercises and passive motion exercises. He was progressed to active motion and global shoulder strengthening exercises at three months. He was released to play the following fall season after follow-up radiographs demonstrated callous formation about the fracture site. He played the entire season with no right shoulder complaints. Scapula fractures are certainly rare in athletic injuries. They only account for 1 percent of all documented fractures and acromion fractures represent only 8-10 percent of those fractures. This case was especially unique because surgical intervention was indicated from this athletic injury. There is some debate on whether or not to fix these fractures surgically, but in this case it was deemed appropriate because of the large amount of displacement and the fact the injury probably occurred several months earlier.

# **Recurrent Shoulder Pain In A Collegiate Football Player**

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An 18 year old college freshman had a history of an arthroscopic Bankart repair in June of 2002 after falling on an outstretched arm during a high school football game. The patient returned to football 4 months post-op after Bankart rehabilitation protocol. At 14 months post-op, this athlete was pulling himself up from a seat on an amusement ride and felt a "ripping" sensation. On evaluation, he had severe pain over the acromioclavicular joint, good rotator cuff strength, no instability, a negative O'Brien's test, and pain with active use of his deltoid. He tried returning to football with an AC pad but continued to have extreme pain over the anterosuperior shoulder. Differential diagnosis at the time included: Acromioclavicular sprain, Anterior labral tear, Unstable Os Acromiale. A MRI was obtained and showed a large os acromiale with fluid in the area consistent with an injury. X-rays taken prior to the first surgery had shown the os acromiale, but the athlete was not experiencing superior shoulder symptoms at that time. The original MRI also showed the os acromiale, but there

was no fluid at the site. A diagnostic arthroscopy was performed to evaluate the labrum and the os. The labrum was intact and healed. The os was found to be very unstable with a gap of approximately 1 cm. An incision was made so the os could be reduced anatomically. Two cannulated screws were placed from anterior to posterior across the os. Wire was then passed through the screws to act as a tension band. Local bone graft, from the spine of the scapula was also placed across the os to aid in healing. Passive range of motion with elevation to 90 degrees and internal/external rotation was allowed during the next three weeks. Active range of motion was begun after this point. By 6 weeks postop, he had full ROM and no pain. The anterior acromion has three centers of ossification that usually fuse by the age of 18. The prevalence of an os acromiale is 1-8 %. These are usually asymptomatic. Some authors believe these to be anatomic variants, as opposed to nonunited ossification centers. In this case, the patient clearly developed clinical and radiographic evidence of a symptomatic os acromiale that required operative stabilization.

# **Acute, Idiopathic Swelling In The Arm Of A Female Collegiate Volleyball Player**

Gage MJ, Thompson RW, Khoo-Summers L, Majewski TL, Evans TA: University of Northern Iowa, Cedar Falls, IA; Washington University, St. Louis, MO; and Barnes-Jewish Hospital, St. Louis, MO

During the off-season, a 21 year-old collegiate All-American volleyball player initially reported idiopathic bruising over the right bicep. Two days later, following weight training, the signs progressed to include obvious swelling and a cyanotic appearance in her arm and fingers. Although she did not report pain at any time, her veins in the right arm were distended. She noted mild weakness but no loss of function. Prior to this episode, she had no history of right shoulder pathology and was fully functional and active. Because this occurred over the holiday vacation, she visited her family physician after consulting her certified athletic trainer one week after the initial appearance of the bruising. The physician identified the possibility of a blood clot and immediately referred her to a specialist who ordered an ultrasound examination. The differential diagnosis included thoracic outlet syndrome, deep vein thrombosis of

the subclavian vein, myositis ossificans, and other neurovascular disorders. A thrombus in the subclavian vein was first revealed though ultrasonography. Five days following the symptoms onset, venography demonstrated basilic, axillary, and subclavian vein thrombosis and possible stenosis at the first rib and clavicle. One day after thrombolytic therapy, a second venogram revealed considerable flow through veins in right shoulder. Five days following the onset of symptoms, the athlete underwent thrombolytic therapy consisting initially of intravenous heparin, followed by urokinase. In addition, she received a self-administered anticoagulant injections of Lovenox (Enoxaparin Sodium) twice daily for one month. Although this successfully dissolved the thrombus, a third venogram, taken one month after initial onset showed narrowing of the right subclavian vein during 90 degrees of shoulder abduction. Therefore, at thirty-days post onset, the athlete underwent paraclavicular thoracic outlet decompression including first rib resection, radical anterior and middle scalenectomy, and brachial plexus neurolysis. Once the decompression was complete and the subclavian vein was exposed, the surgeon determined that venous wall thickening had occurred. The subclavian vein was then reconstructed with a saphenous vein patch taken from the right thigh. In addition, to augment blood flow through the subclavian vein during the postoperative period, a right radial-cephalic arteriovenous fistula, joining the cephalic vein and radial artery, was created at the wrist. The entire surgical procedure lasted ten-hours. There were no post-operative complications. Distal pulses, range of motion, and motor responses were normal. In the hospital, she began a mild rehabilitation protocol with emphasized pulmonary capacity, supine to sitting transfers, and neck and shoulder motion. At six days post-surgery, she began her home rehabilitation program and at two weeks post-surgery, she began supervised rehabilitation at the collegiate athletic training room, including range of motion, as well as rotator cuff and scapular stabilization and strengthening exercises. Her progress was rapid and at 70 days post-surgery, she began limited volleyball activities and weight training. She was cleared to play competitive volleyball 6 months following surgery, just prior to start of her senior collegiate season. She continued rehabilitation throughout the season and returned to her previous performance level. Deep vein thrombosis



involving the basilic, axillary, and subclavian veins is an uncommon finding in athletes. This condition, also referred to as Paget-Schroetter syndrome or effort thrombosis, is associated with strenuous upper extremity activity. If left untreated, ischemia and permanent functional loss can occur. In this case, it was uncertain if repetitive overhead activity or weight training was the causative factor. Patients who develop this type of venous blockage typically report some degree of increasing pain in addition to swelling and cyanosis. In the case of our athlete, she reported no pain or tenderness prior to surgery. Furthermore, most cases of deep vein thrombosis can be treated successfully with thrombolytic therapy. Unlike this case, rib resection and vascular reconstruction is not always necessary. Despite the initial prognosis that this condition would end her volleyball career, she completed her senior season and maintained her same performance level. In summary, although deep vein thrombosis of the basilic, axillary, and subclavian arteries is an uncommon finding, athletic trainers should beware of its insidious onset, the sequence of diagnostic testing, the surgical and nonsurgical treatment options, as well as the prognosis for a return to competitive athletics.

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#### **Elbow And Upper Arm Pain In A Collegiate Football Player**

Martini JM, Hauth JM, Vanic KA: East Stroudsburg University, East Stroudsburg, PA

A 21-year old male NCAA Division II college football player reported to the athletic training staff during competition with a chief complaint of right upper arm pain. As the athlete was attempting to make a tackle on an opponent his right elbow was forced into extension. The athlete described hearing a "snapping" noise in his right elbow. During a post game evaluation, the athlete reported noticeable stiffness and decreased strength in the right arm. The athlete has no previous history of injury to his right elbow, upper arm or shoulder. The athlete was referred for orthopedic evaluation. Physical examination revealed deformity at the distal insertion of the Biceps Brachii muscle and the medial cubital fossa. The athlete was point tender at the right medial insertion of the Biceps Brachii and into the region of the medial epicondyle. No discoloration was noted, however, mild edema was present over the medial insertion of the Biceps Brachii. On

field and orthopedic assessment were completed to rule out avulsion of the distal attachment of the Biceps Brachii muscle, Biceps Brachii strain, avulsion fracture of the medial epicondyle of the Humerus. Radiographs were negative for fracture, however, results of magnetic resonance imaging (MRI) revealed longitudinal tears in the distal Biceps Brachii tendon. The athlete was placed in a posterior splint with compressionette and re-evaluated 14 hours post injury. In addition to symptoms previously noted, the athlete reported feeling "weak". Along with immobilization, the initial treatment plan consisted of cryotherapy and electrical stimulation for pain management. Subsequent to orthopedic evaluation and the results of diagnostic testing, the athlete was placed in a Donjoy® elbow brace and the treatment plan was revised to include progressive strengthening exercises for the elbow and upper arm. One week post injury the athlete began therapeutic heat treatments followed by sport specific training and conditioning exercises. Two weeks post injury the athlete was returned gradually to practice wearing the Donjoy® prophylactic elbow brace. After missing two games, the athlete successfully returned to play without incident or insult. The occurrence of a partially ruptured distal Biceps Brachii tendon is a relatively rare event. The literature suggests partial tears are more difficult to diagnose than complete ruptures. Partial ruptures are most commonly seen in the dominant extremity of men between 40 and 60 years of age and with an associated unexpected force applied to the flexed arm. Ruptures usually occur at the tendon insertion in the radial tuberosity in an area of preexisting tendon degeneration. The diagnosis is made on the basis of a painful, tearing sensation in the antecubital region. In this case, a young male athlete with no history suffered this unique injury while attempting to make a tackle with a flexed arm. His return to full activity with 21 days supports the need for early recognition and management.

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#### **Upper Extremity Deep Vein Thrombosis In A NCAA Collegiate Football Player**

Sibold JS: West Virginia Wesleyan College, Buckhannon, WV

After routine and regular weight training, a 21 year-old collegiate football player reported to the Athletic Training Room with the chief complaint of left upper extremity

pain, swelling, and tingling in the hand. He reported no acute onset of these symptoms, only stating that he had completed what was a "normal" workout, at the usual intensity and duration, during which the swelling and pain increased gradually. The athlete denied any ergogenic or other performance enhancing substance use, and also reported that this was the first time this had ever happened. The athlete was initially evaluated by the head athletic trainer and subsequently referred to the team physician for follow up evaluation that afternoon. Visual observation revealed a significant and obvious increase in the left upper extremity girth as compared to the uninvolved right side. The certified athletic trainer began the evaluation by clearing the neurovascular supply to the arm and hand by taking bilateral blood pressures as well as bilateral distal pulses at the carotid, brachial, and radial pulses. Also, sensation was tested bilaterally via stereographic sharp-dull discrimination in dermatomes C5-T1. Pulses and sensations were bilaterally equal, and blood pressures were symmetrical. Further testing revealed increased surface temperature at the proximal left upper extremity as compared to the uninvolved side. There were no palpable axillary lymph nodes, and the athlete's oral and tympanic temperatures were 37.6° Celsius. Upon girth measurements via tape measure, the athlete was found to have increased circumferences at both the deltoid tuberosity and radial head when compared to the uninvolved side. The girth differences between involved (left) and un-involved (right) were 3.7 cm and 2.8 cm at the deltoid and radial head measures respectively. These landmarks were used for further regular measures throughout this case because of ease of palpation and consistency of measures. Further orthopedic testing was then initiated for the cervical spine and upper quarter to rule out musculoskeletal involvement and all tests were unremarkable. The differential diagnoses considered were thoracic outlet syndrome, cellulitis, anaphylaxis, and /or deep vein thrombosis. Upon referral to the team physician for follow up, the athlete was diagnosed as having an upper extremity deep vein thrombosis. This diagnosis was confirmed via blood analysis, x ray, and computerized axial tomography (CAT) scan. The results of this imaging revealed an occlusion of the left subclavian vein without extrinsic mass. The athlete was managed initially via an intravenous dose of the anti-coagulant heparin in order to decrease the potential for extension and/or migration of the thrombus. The athlete

was then managed conservatively via oral anti-coagulants for three months. During this time, the athlete reported to the head athletic trainer for daily chest wall flexibility exercises and girth measurements of the upper extremity as per the team physician. The athlete was restricted from all spring football contact and only allowed to participate in non-contact conditioning drills after remission of the thrombosis had been seen via follow up CAT scan. The athlete was then cleared to return to full participation the following season. This case is unique in that it involved a young, active athlete rather than the more commonly seen upper extremity deep vein thrombosis in patients with cancers and those with central line placement. Also, this athlete had no other hypercoagulable blood characteristics, history of other deep vein thrombosis, or comorbid diseases that may predispose one to upper extremity deep vein thrombosis. This pathology occurs very rarely (2/100,000) and only produces symptoms in 23-50% of victims (DeMillo, 1999; Heron, Loziquez, Alhenc-Gelas, Emmerich, & Fiessinger, 2000; Stephens, 1997). By presenting this case report, the author hopes to bring heightened awareness to sports medicine professionals as to the clinical presentation, management options, and current medical knowledge base regarding upper extremity deep vein thrombosis in the athletic population.

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